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BEING

OCCASIONAL DISCUSSIONS AND COMPILATIONS OF METEOROLOGICAL DATA

RELATING TO

INDIA AND THE NEIGHBOURING COUNTRIES.

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II.—DISCUSSION OF THE RESULTS OF THE HOURLY OBSERVATIONS RECORDED AT 29 STATIONS IN INDIA GIVEN IN VOLUMES V, IX AND X OF THE INDIAN METEOROLOGICAL MEMOIRS.

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II.—Discussion of the results of the hourly observations recorded at 29 stations in India given in volumes V, IX and X of the India Meteorological Memoirs by JOHN ELIOT, M. A., F.R.S., C.I.E., *Meteorological Reporter to the Government of India and Director General of Indian Observatories.*

INTRODUCTION.

The present memoir is devoted to a discussion of the data contained in the memoirs of the hourly observations at 29 stations in India, published in the India Meteorological Memoirs, Vols. V, IX and X, chiefly with the object of investigating the relations of the diurnal variations of the air pressure to the diurnal changes of other elements of meteorological observation.

There is no doubt from the results of recent investigations that the diurnal oscillation of air pressure is due in part to general meteorological actions, common to the whole atmosphere, and in part to localized actions, the intensity of which varies very considerably at different stations.

The chief object of the present memoir is to endeavour to separate these local effects and actions from the general effects and actions, and to determine, so far as is at present possible, the causes to which they are due.

The data accumulated in the memoirs are examined and discussed in the following order in eight chapters :—

(1) Solar radiation;
(2) Terrestrial radiation;
(3) Ground temperature;
(4) Temperature of the air;
(5) Aqueous vapour pressure;
(6) Cloud;
(7) Air movement;
and
(8) Air pressure.

The final chapter (Chapter *g*) is devoted to an examination of the relations between the diurnal and annual changes of these elements, and an investigation into the more important phenomena of the diurnal oscillation of pressure in India.

CHAPTER I.

SOLAR RADIATION.

The hourly observations were taken of this element by means of solar radiation thermometers, the bulbs of which were coated with lamp-black and enclosed in large bulbs of ordinary glass from which the air was partially exhausted. The hourly observations recorded on clear days at nine stations were tabulated and given in the memoirs. A summary of the data is given in the following table (Table I) and curves plotted from the data will be found in Plates VI and VII.

A partial examination of the observations obtained by the use of these instruments in India, which I made in 1889, indicated that they were of little value, as the solar radiation thermometers were liable to large irregular changes which made them unfit for accurate observation, except under conditions which it was not possible to obtain in India, except perhaps at the first class observatories.

The late Mr. Hill, Meteorological Reporter to the Government of the North-Western Provinces, subsequently (in 1890) went more fully into the question and came to similar conclusions. His conclusions were briefly given in the Annual Report for 1889.

They were as follows:—

"1st.—There is no advantage whatever in attempting to correct the observations to a common standard. The uncorrected readings in many, if not most, cases agree better than those to which the corrections have been applied. A few days' observations under identical conditions are not sufficient to determine the correction with any approach to accuracy. The thermometers are so variable in their indications that in one ordinary case which I have worked out, it would seem that at least 44 months' comparative readings would be required to furnish an average correction with a probable error of only one-tenth of a degree.

2nd.—The differences between the indications of two thermometers placed side by side are in very many instances subject to an annual variation, showing that the correction to a common standard cannot be made by adding or subtracting a fixed quantity, but that the amount of this correction is variable, and perhaps capable of being expressed as a function of the temperature indicated. This, I believe, has already been pointed out by Mr. Whipple of Kew Observatory.

3rd.—The older thermometers, even after correction, on the whole, give lower readings than the newer ones. Some of the latter, when compared with the oldest thermometer of the set, appear to fall off considerably in sensitiveness even in the short period of twelve months. It is not, however, always the newest thermometer which shows this falling off most distinctly; sometimes an instrument two or three years old decreases in sensitiveness more rapidly than a perfectly new one; sometimes also an instrument after remaining nearly constant in its indications for several months, as compared with the oldest of the set, suddenly shows a rapid and unaccountable falling off in sensitiveness.

4th.—The indications of the instruments are thus in most cases totally unreliable, and the observations consequently worthless. The only possible exceptions, I can see, to this sweeping condemnation are observations made with instruments which have been in constant use for ten years or more and which may perhaps be assumed to have arrived at a constant condition as regards sensitiveness."

Davis in his Elementary Meteorology writes as follows of the solar radiation thermometer and its use:—

"It is sometimes desired to obtain an indication of the intensity of sunshine, independent of the temperature of the air. This is roughly effected by a maximum thermometer having the bulb coated with dull lamp-black, the thermometer being enclosed in a glass tube from which the air has been exhausted. The lamp-black on the bulb absorbs a large share of the sunshine, and the absence of air around the bulb prevents cooling by conduction. A temperature much above that of the surrounding air is thus reached. It is customary to record simply the excess of the maximum thus gained over that of the ordinary maximum reading. This excess, however, varies so greatly with the conditions surrounding the instrument that it is not admissible to regard observations with black-bulb thermometers as having any precise or comparable value. The instrument cannot be recommended for ordinary observation." (*Vide* page 61, Elementary Meteorology by Davis).

In the following table are given the values of the mean hourly excess of insolation temperature on clear days in three seasons of the year for nine stations. The data are plotted as curves in Plates VI and VII. An examination of the data shows that they are more or less unsatisfactory and are not inter-comparable. It is hence not considered necessary to discuss them, and the results are solely given for reference by Meteorologists who may be interested in the subject.

TABLE I.—*Giving mean hourly excess of insolation temperature at the hours of apparent time.*

Station.		7h.	8h.	9h.	10h.	11h.	12h.	13h.	14h.	15h.	16h.	17h.	Maximum. Epoch.	Maximum. Value.
		°	°	°	°	°	°	°	°	°	°	°		°
CHITTAGONG.	Mean, January and February.	10·3	34·7	45·0	49·3	49·1	52·0	53·1	49·3	30·0	16·4	3·8	0-43 P.M.	53·4
	„ March and April.	23·4	39·2	44·7	50·9	52·1	53·1	51·3	50·7	46·2	32·3	19·8	11-52 A.M.	53·2
	„ October to December.	19·2	40·3	49·2	52·1	55·6	57·2	57·0	54·1	19·9	10·9	5·4	0-23 P.M.	57·3
	„ 7 months.	17·6	38·1	46·3	50·8	52·3	54·1	53·8	51·4	32·0	19·9	9·7	0-22 „	54·2
CUTTACK.	Mean, January and February.	...	9·4	21·3	32·2	48·3	56·2	57·1	56·3	46·1	20·5	2·8	1-2 P.M.	57·2
	„ March and April.	3·3	17·4	31·2	42·8	50·8	54·9	55·3	50·6	41·9	26·3	7·8	0-35 „	55·5
	„ October to December.	...	9·1	21·6	33·7	49·2	55·7	55·1	49·0	37·5	13·2	...	0-4 „	56·4
	„ 7 months.	...	12·0	24·7	36·2	49·4	55·6	55·8	52·0	41·8	20·0	...	0-33 „	55·9
GOALPARA.	Mean, January and February.	3·3	14·5	32·8	45·2	51·1	55·2	52·2	39·8	28·4	13·0	1·6	0-5 P.M.	55·5
	„ March and April.	4·6	22·5	39·2	48·9	54·5	54·8	53·9	49·7	39·1	27·6	13·8	11-45 A.M.	54·9
	„ October to December.	4·1	12·0	29·6	46·8	54·2	56·3	54·6	46·1	41·6	21·0	4·1	0-3 P.M.	56·4
	„ 7 months.	4·0	16·3	33·9	47·0	53·3	55·6	53·6	45·2	36·4	20·5	6·5	0-2 „	55·7

TABLE I.—*Giving mean hourly excess of insolation temperature at the hours of apparent time*—concluded.

Station.		7h.	8h.	9h.	10h.	11h.	12h.	13h.	14h.	15h.	16h.	17h.	Maximum.	
													Epoch.	Value.
		°	°	°	°	°	°	°	°	°	°	°		°
PATNA.	Mean, January and February .	9·6	25·5	48·6	55·0	57·9	58·5	58·1	55·0	48·2	36·1	15·4	0-6 P.M.	58·5
	„ March and April . .	22·9	40·8	53·4	57·2	58·5	57·6	56·7	53·6	45·8	36·5	20·4	11-5 A.M.	58·6
	„ October to December .	4·5	21·1	46·1	54·0	57·0	58·9	58·3	55·3	49·8	37·4	13·9	0-16 P.M.	59·1
	„ 7 months . . .	12·3	29·1	49·4	55·4	57·8	58·3	57·7	54·6	47·9	36·7	16·6	11-57 A.M.	58·3
HAZARIBAGH.	Mean, January and February .	19·7	43·7	53·6	57·6	58·9	59·3	57·6	54·9	49·0	37·9	15·5	11-41 A.M.	59·6
	„ March and April . .	28·4	44·9	53·3	56·2	57·6	57·1	56·2	53·1	48·1	41·0	27·7	11-14 „	57·7
	„ October to December .	13·6	38·2	50·8	56·0	57·4	58·0	57·0	55·1	51·4	42·1	16·7	11-53 „	58·1
	„ 7 months . . .	20·6	42·3	52·6	56·6	58·0	58·1	56·9	54·4	49·5	40·3	20·0	11-35 „	58·2
DHURRI.	Mean, January and February .	5·1	17·6	29·8	37·9	47·6	51·3	49·3	45·2	33·2	21·8	2·1	0-9 P.M.	51·6
	„ March and April . .	11·2	27·5	36·8	40·8	47·7	52·3	52·3	49·6	44·4	34·7	18·8	0-30 „	52·3
	„ October to December .	3·3	17·7	29·6	39·1	48·9	51·8	51·0	49·8	37·2	24·6	3·3	0-17 „	52·0
	„ 7 months . . .	6·5	20·9	32·1	39·3	48·1	51·8	50·9	48·2	38·3	27·0	8·1	0-18 „	52·1
LUCKNOW.	Mean, January and February .	20·8	40·7	53·2	55·5	54·6	53·3	51·3	47·7	42·1	29·2	...	10-17 A.M.	55·8
	„ March and April . .	27·8	44·1	52·1	55·8	57·4	57·6	55·8	52·3	45·9	37·5	24·5	11-36 „	57·7
	„ October to December .	17·6	36·3	47·0	50·6	52·6	52·1	50·0	45·8	39·0	26·9	...	11-2 „	52·6
	„ 7 months . . .	22·1	40·4	50·4	54·0	54·9	54·3	52·4	48·6	42·3	31·2	...	11-6 „	55·0
AGRA.	Mean, January and February .	...	...	50·8	62·1	66·2	67·1	65·4	61·3	53·9	39·3	16·6	11-52 A.M.	67·3
	„ March and April . .	...	34·6	53·9	61·2	64·8	65·4	64·4	60·7	53·4	42·8	24·3	11-53 „	65·5
	„ October to December .	...	...	43·9	57·4	62·3	63·3	61·9	57·7	50·3	37·0	...	11-55 „	63·4
	„ 7 months . . .	...	...	49·5	60·2	64·4	65·3	63·9	59·9	52·5	39·7	...	11-53 „	65·4
LAHORE.	Mean, January and February .	...	31·7	45·0	51·1	52·2	51·0	50·4	49·8	46·4	29·9	...	10-59 A.M.	52·2
	„ March and April . .	21·4	39·1	49·6	55·0	56·4	54·0	53·3	52·3	48·7	35·8	6·7	10-52 „	56·6
	„ October to December .	...	25·0	39·3	47·5	49·9	50·5	49·0	46·6	40·9	30·6	...	11-47 „	50·6
	„ 7 months . . .	...	31·9	44·6	51·2	52·8	51·8	50·9	49·6	45·3	32·1	...	11-7 „	52·9

CHAPTER II.

NOCTURNAL RADIATION.

The observations for the determination of this element consist of hourly readings of a spirit thermometer laid on a pad of woollen blanket one foot square, which rests on the ground. The difference of these and the corresponding readings of the standard or dry bulb thermometer, 4 feet above the ground, under a thatched shed open on all sides, are taken as the data for the following table. The readings were taken from midnight to 5 or 6 A.M., and from 6 or 7 P.M. to the following midnight. Thus each day's readings consist of two, six or seven hour series, one of which begins, the other ends with midnight. The hourly means of all the observations having been computed for each month, it is generally found that the two midnight means differ more or less from each other. In order to combine them, therefore, as a continuous series, the mean of the two midnight means is adopted for that hour and the + or — difference between this mean and the mean midnight recorded value is applied as a correction to the series which it begins or terminates. The observations of these instruments, unlike those of solar radiation thermometers, are strictly comparable.

The following table gives a summary of the mean seasonal data of the differences between the shaded thermometer and the nocturnal radiation thermometer for stations in the interior of Central and Northern India (excepting Assam). The data give means for the three seasons of the year, *viz.*, the cold weather, the hot weather and the rainy season, and for the typical months of these seasons, *viz.*, December, April and July. It may be noted that the cold weather season includes the period, October to February; the hot weather, March to May; and the rainy season, June to September.

TABLE II.—*Mean differences between the temperature of the air and the temperature indicated by the grass radiation thermometer in Extra-Tropical India Inland.*

Station.	Elevation.	Mean 7 P.M. to 5 A.M.			Mean, typical month.		
		Cold weather.	Hot weather.	Rainy season.	December.	April.	July.
	Feet.	°	°	°	°	°	°
Patna	183	5·2	5·3	2·6	5·5	5·9	2·3
Hazaribagh	2,007	11·1	10·0	3·4	11·7	10·8	2·7
Allahabad	309	10·6	10·2	3·3	11·5	11·1	2·5
Lucknow	370	9·5	8·2	3·6	10·2	8·8	2·6
Agra	555	10·7	10·5	5·0	11·2	11·1	4·5
Roorkee	887	8·5	7·8	3·3	8·7	8·7	2·2
Lahore	702	8·6	7·5	4·7	8·4	7·4	4·0
Deesa	466	10·5	9·4	3·4	10·8	10·3	2·0
Jaipur	1,431	10·8	9·3	4·2	11·5	10·0	3·2
Jubbulpore	1,327	8·3	9·0	3·0	8·6	9·4	2·2
Mean	...	9·4	8·7	3·7	9·8	9·4	2·8

The data indicate that the differences between the readings of the air and grass radiation thermometers are fairly constant throughout the cold and hot weather periods, averaging 9°. The differences vary slightly from station to station, depending in part upon the humidity of the atmosphere, and in part upon local peculiarities of exposure.

The differences between the readings of the two thermometers are small during the south-west monsoon period and average 3°·7 for the preceding stations. They vary to a smaller extent during this period than the preceding two periods of the year, and are smallest in the coast districts for which they average 2°·7, and increase into the interior, and are greatest in the Punjab and the drier districts of the North-Western Provinces and Rajputana.

TABLE III.—*Giving the maximum and minimum differences and their hours of occurrence on the mean night of the year at stations in the interior of Northern and Central India (Extra-Tropical India Inland.)*

STATION.	Maximum	Epoch.	Minimum.	Epoch.
	°		°	
Patna	4·6	7 P.M.	4·2	Midnight.
Hazaribagh	8·4	8 P.M. to 10 P.M.	8·0	7 P.M. and 5 A.M.
Allahabad	8·4	7 P.M. to 9 P.M.	7·6	5 A.M.
Lucknow	7·3	8 P.M. to 9 P.M. and 2 A.M.	7·0	5 A.M.
Agra	9·1	3 A.M. and 4 A.M.	7·9	7 P.M.
Roorkee	6·8	7 P.M.	6·3	5 A.M.
Lahore	7·4	8 P.M.	6·6	5 A.M.
Deesa	8·6	7 P.M.	7·4	5 A.M.
Jaipur	8·4	9 P.M.	8·1	7 P.M.
Jubbulpore	6·9	7 P.M. and 5 A.M.	6·4	Midnight.
Mean	7·6	......	7·0	......

An examination of the whole of the data supports fully the inference suggested by the figures of the preceding table that the mean differences between the air temperature at four feet above the ground and the temperature indicated by the grass radiation thermometer are nearly constant in amount during the night. The differences for stations in Extra Tropical India are usually greatest shortly after sunset, and diminish very slightly until the morning hours (about 5 A.M.) shortly before sunrise.

It will be seen from the data in Table II that the differences for the cold and hot weather seasons differ very little in amount, and it is hence more satisfactory, on the whole, to divide the year into two seasons, *viz.*, the dry season or season of dry land

winds and the wet season or season of damp winds of oceanic origin. The following gives comparative data from this standpoint for stations in the interior of Northern India :—

TABLE IV.—*Mean differences between the temperature of the air and the temperature indicated by the grass radiation thermometer during each season, and also their maximum and minimum values and their epochs at stations in the interior of Northern and Central India (Extra-Tropical India Inland).*

Station.	Mean difference 7 P.M. to 5 A.M.		7 P.M. to 5 A.M.				7 P.M. to 5 A.M.			
	Dry season.	Wet season.	Dry season.				Wet season.			
	October to May.	June to September.	Maximum during night.	Epoch.	Minimum during night.	Epoch.	Maximum during night.	Epoch.	Minimum during night.	Epoch.
	°	°	°		°		°		°	
Patna	5·3	2·6	5·9	7 P.M.	5·1	Midnight to 1 A.M.	2·8	7 P.M.	2·5	10 P.M. to midnight.
Hazaribagh	10·7	3·4	10·9	11 P.M.	10·2	7 P.M.	3·6	8 P.M. and 10 P.M.	3·2	2 to 5 A.M.
Allahabad	10·5	3·3	10·9	7 P.M. to 9 P.M.	10·0	3 A.M. to 5 A.M.	3·4	7 P.M. to 9 P.M.	3·1	5 A.M.
Lucknow	9·0	3·6	9·2	2 A.M.	8·8	10 P.M. to midnight.	3·8	8 P.M. to 10 P.M.	3·3	5 A.M.
Agra	10·6	5·0	11·0	4 A.M.	9·9	7 P.M.	5·6	5 A.M.	4·0	7 P.M.
Roorkee	8·2	3·3	8·6	7 P.M.	7·8	4 A.M. and 5 A.M.	3·5	4 A.M.	3·0	7 P.M.
Lahore	8·2	4·7	8·8	7 P.M. and 8 P.M.	7·5	5 A.M.	4·7	9 to 11 P.M. 2·35 A.M.	4·6	8 P.M. midnight 1 and 4 A.M.
Deesa	10·1	3·4	11·1	7 P.M.	9·4	5 A.M.	3·6	8 P.M.	3·2	Midnight.
Jaipur	10·2	4·2	10·5	7 P.M. to 9 P.M.	10·0	2 A.M.	4·6	4 A.M.	3·2	7 P.M. and 9 P.M.
Jubbulpore	8·6	3·0	8·9	8 P.M.	8·2	Midnight.	3·4	5 A.M.	2·8	9 P.M. to midnight.
Mean	9·1	3·7	9·6	......	8·7	......	3·9	......	3·3	......

The mean difference in the dry season for these ten stations is 9°·1, and the mean range of variation during the night is only 0·9°. In the wet season the mean difference is 3·7° and the mean range of variation 0·6°. It may be noted that the observatory at Patna is in the immediate vicinity of the bazar, and hence it is probable the small differences at that station are due to the influence of the smoke from the numerous fire lighted in the evening for cooking purposes.

In the following Tables V to VII are given corresponding data for stations in the interior of the Peninsula or Tropical India:—

TABLE V.—*Giving mean seasonal differences between the temperature of the air and temperature indicated by the grass radiation thermometer at stations in the interior of Tropical India:—*

Station.	Elevation.	Mean, 7 P.M. to 5 A.M.			Mean, Typical month.		
		Cold Weather.	Hot Weather.	Rainy Season.	December.	April.	July.
	Feet.	°	°	°	°	°	°
Nagpur	1,025	13·7	13·6	4·9	15·5	14·2	4·3
Poona	1,840	11·5	8·4	3·1	11·9	7·8	2·6
Belgaum	2,524	8·2	6·1	1·4	9·2	6·0	1·0
Bellary	1,475	3·3	3·1	2·6	3·1	3·2	2·3
Trichinopoly	255	1·9	1·7	1·4	1·9	1·7	1·3
Mean of Nagpur, Poona and Belgaum.		11·1	9·4	3·1	12·2	9·3	2·6

The differences vary so largely at these stations as to suggest very different exposures. At Nagpur the observatory is situated at a considerable distance from the city on a slightly elevated tract of ground, and hence most favourably situated for these observations. The observatories at Bellary and Trichinopoly were, on the other hand, on relatively low ground, quite close to the bazars, and the smoke from the fires (made chiefly by leaves, small twigs and straw giving dense smoke) lighted in the evening for cooking the evening meals of the natives probably hung over the observatories during the night. They were shifted to less objectionable sites, distant from the bazars, some years ago.

TABLE VI.—*Giving the mean amplitudes and epochs of the maximum and minimum values of the differences between the air temperature and temperature indicated by the grass radiation thermometer at stations in the interior of Tropical India:—*

Station.	Maximum.	Epoch.	Minimum.	Epoch.
	°		°	
Nagpur	10·9	10 P.M. to 11 P.M.	10·4	7 P.M.
Poona	8·5	4 A.M.	5·0	7 "
Belgaum	6·2	4 "	4·5	7 "
Bellary	4·2	5 "	1·6	7 "
Trichinopoly	2·7	5 "	0·7	7 "
Mean	6·5	...	4·4	...

The maximum differences were observed at these stations in the morning (about 4 to 5 A.M.) and the minimum in the evening (7 P.M.). The contrast between the values of the maximum and minimum at four of these stations is marked, more especially at Trichinopoly and Bellary. This, it is evident, is in full agreement with the peculiar conditions of the exposure of the grass radiation thermometer at these two stations pointed out in the preceding paragraph.

The following gives a summary of the data for the two seasons of the year, *viz.*, the dry season and the wet season. The contrast between the data for the two seasons is much less marked than at stations in Northern and Central India.

TABLE VII.—*Giving mean differences between the temperature of the air and the temperature indicated by the grass radiation thermometer in the dry and wet seasons and the mean maximum and minimum values of the differences and their epochs, at stations in Tropical India* :—

STATION.	MEAN DIFFERENCE 7 P.M. to 5 A.M. Dry Season. November to May.	Wet Season. June to October.	7 P.M. to 5 A.M. Dry Season. Maximum during night.	Epoch.	Minimum during night.	Epoch.	7 P.M. to 5 A.M. Wet Season. Maximum during night.	Epoch.	Minimum during night.	Epoch.
	°	°	°		°		°		°	
Nagpur . . .	14·1	6·0	14·4	10 P.M. and 11 P.M.	13·6	7 P.M.	6·2	9 P.M. and 10 P.M.	5·8	3 A.M.
Poona	10·2	3·7	11·5	4 A.M.	6·6	7 „	4·3	4 A.M.	2·7	7 P.M.
Belgaum . . .	8·0	1·7	9·0	4 „	6·7	7 P.M. and 8 P.M.	2·3	4 „	1·4	7 „
Bellary . . .	3·3	2·6	4·9	5 „	1·4	„	3·3	5 „	1·8	7 „
Trichinopoly . .	1·8	1·4	3·1	5 „	0·6	7 P.M.	2·1	5 „	0·8	7 „
Mean .	7·5	3·1	8·6	...	5·8	...	3·6	...	2·5	...

The data for these stations are unsatisfactory. They appear to show that the radiation from objects near the earth's surface (as indicated by the differences between the readings of the grass radiation thermometer and the ordinary thermometer in the shade, is least in amount about 7 P.M. and increases during the night and until 4 A.M. or 5 A.M. in the early morning. It is probable that this at Poona and Belgaum is, in part, if not entirely, due to the decreasing influence during the night hours of the sea winds which prevail at these two stations during the wet monsoon and to the alternation of land and sea breezes in the dry monsoon. This influence is, it may be noted, also exhibited in the cloud curves (Figs. 13 to 16 in Plates XLIV and XLII). The explanation in the cases of Bellary and Trichinopoly has been given in the preceding page.

In the following Tables, VIII to X, are given corresponding data for stations in the coast districts of India and in the damp valley of the Brahmaputra. (Tropical and Extra-Tropical Coasts and Assam) :—

TABLE VIII.—*Giving mean seasonal differences between the temperature of the air and the temperature indicated by the grass radiation thermometers at coast stations in India and at stations in Assam.*

STATION.	Elevation.	MEAN 7 P.M. TO 5 A.M. Cold weather.	Hot weather.	Rainy season.	MEAN, TYPICAL MONTH. December.	April.	July.
	Feet.	°	°	°	°	°	°
Rangoon	41	6·1	3·9	2·3	6·1	3·7	1·9
Chittagong	87	7·2	4·4	3·5	7·8	4·6	4·2
Kurrachee	49	8·2	6·2	2·2	8·3	6·7	1·8
Aden	94	4·2	3·1	3·9	4·0	3·2	3·4
Dhubri	115	8·2	5·5	2·7	9·0	5·0	2·1
Sibsagar	333	5·2	4·4	3·5	6·2	4·3	3·6
Mean .	...	6·5	4·6	3·0	6·9	4·6	2·8

The preceding data indicate that the differences due to radiation are greatest in the cold weather and least in the rains and are intermediate in value in the hot season when

local sea winds obtain at these coast stations. The data for Sibsagar indicate that the differences are small for all seasons in the Upper Assam Valley and are less in the cold weather than at the coast stations.

TABLE IX.—*Giving the mean values and epochs of the maximum and minimum differences between the air temperature and the temperature indicated by the grass radiation thermometer at coast stations in India and stations in Assam.*

Station.	Maximum.	Epoch.	Minimum.	Epoch.
	°		°	
Rangoon	4·4	1 A.M.	4·2	7 P.M. to 8 P.M. and 11 P.M. to midnight.
Chittagong	5·9	8 P.M. to 10 P.M.	4·9	4 A.M. to 5 A.M.
Kurrachee	6·0	10 P.M.	4·7	7 P.M.
Aden	4·1	Midnight	3·3	7 P.M.
Dhubri	6·2	8 P.M.	5·2	5 A.M.
Sibsagar	5·9	7 "	3·8	4 A.M. to 5 A.M.
Mean .	5·4	...	4·4	...

The epochs of the maximum and minimum values differ considerably. In the Assam Valley and at Chittagong the maximum occurs at 7 P.M. to 8 P.M. and the minimum in the early morning from 4 A.M. to 5 A.M., or practically at the same hours as in the case of the interior stations in Extra-Tropical India. This is probably due to similar causes, namely, the occasional formation of a thin veil of cloud in the areas represented by these stations, due to cooling during the night or early morning hours.

TABLE X.—*Giving mean data for the two seasons of the year,* viz., *the dry and wet seasons and the epochs of the maximum and minimum values on the mean night representative of each season at coast stations in India and stations in Assam.*

STATION.	MEAN DIFFERENCE 7 P.M. TO 5 A.M.		7 P.M. TO 5 A.M.				7 P.M. TO 5 A.M.			
	Dry Season.	Wet Season.	Dry Season.				Wet Season.			
	October to May.	June to September.	Maximum during night.	Epoch.	Minimum during night.	Epoch.	Maximum during night.	Epoch.	Minimum during night.	Epoch.
	°	°	°		°		°		°	
Rangoon . . .	5·3	2·3	5·4	1 A.M. to 3 A.M.	5·2	5 A.M.	2·4	11 P.M. to midnight.	2·1	7 to 8 P.M.
Chittagong . .	6·5	3·5	7·1	8 P.M. to 10 P.M.	5·7	4 A.M. to 5 A.M.	3·6	10 P.M.	3·3	5 A.M.
Kurrachee . . .	7·5	2·2	7·9	10 P.M.	6·3	7 P.M.	2·7	5 A.M.	1·3	7 P.M.
Aden . . .	3·8	3·9	3·9	11 P.M. to midnight and 4 A.M. to 5 A.M.	3·5	7 P.M.	4·5	1 "	2·9	7 "
Dhubri . . .	7·2	2·7	7·9	7 P.M. to 8 P.M.	6·5	5 A.M.	2·9	9 P.M.	2·4	7 "
Sibsagar . . .	4·9	3·5	6·5	7 P.M.	4·1	5 P.M.	4·6	7 "	3·0	4 A.M.
Mean .	5·9	3·0	6·5	..	5·2	...	3·5	...	2·5	...

In the following tables XI to XIII are given corresponding data for hill stations in Northern and Central India.

TABLE XI.—*Giving mean seasonal differences between the temperature of the air and the temperature indicated by the grass radiation thermometer at hill stations in India.*

STATION.	Elevation.	MEAN, 7 P.M. TO 5 A.M.			MEAN, TYPICAL MONTH.		
		Cold Weather.	Hot Weather.	Rainy Season.	December.	April.	July.
	Feet.	°	°	°	°	°	°
Pachmarhi	3,528	12·3	12·4	4·1	12·6	13·0	2·8
Simla	7,070	10·2	9·5	7·7	10·5	9·5	?
Leh	11,503	12·5	11·5	12·2	11·6	11·5	11·8
Mean		11·7	11·1	8·0	11·6	11·3	7·3

TABLE XII.—*Giving the mean values and epochs of the maximum and minimum differences between the air temperature and temperature indicated by the grass radiation thermometer at hill stations in India.*

STATION.	Maximum.	Epoch.	Minimum.	Epoch.
	°		°	
Pachmarhi	10·5	5 A.M.	8·0	7 P.M.
Leh	13·0	5 „	10·6	7 „
Simla	10·1	4 „	8·5	7 „
Mean	11·2		9·0	

TABLE XIII.—*Giving mean differences for the dry and wet seasons of the year and the values and epochs of the maximum and minimum differences at hill stations in India.*

STATION.	MEAN DIFFERENCE 7 P.M. TO 5 A.M.		7 P.M. to 5 A.M.				7 P.M. TO 5 A.M.			
	Dry Season.	Wet Season.	Dry Season.				Wet Season.			
	October to May.	June to September	Maximum during night.	Epoch.	Minimum during night.	Epoch.	Maximum during night.	Epoch.	Minimum during night.	Epoch.
	°	°	°		°		°		°	
Pachmarhi	12·3	4·1	13·6	5 A.M.	10·4	7 P.M.	4·3	1 A.M. to 2 A.M. & 4 A.M. to 5 A.M.	3·2	7 P.M.
Simla	9·9	7·7	10·6	2 A.M. & 5 A.M.	9·0	7 „	8·5	3 A.M.	6·5	7 „
Leh	12·1	12·2	13·2	5 A.M.	10·4	7 „	12·7	3 A.M. to 4 A.M.	11·0	7 „
Mean	11·4	8·0	12·5		9·9		8·5		6·9	

Table XI shows that the differences between the readings of the grass radiation thermometer and the thermometer in the shade are larger at the hill than the plain stations. They are especially large at Pachmarhi in the dry season and at Leh throughout the year. The differences average 12°·3 at Pachmarhi in the dry season and 4°·1 in the rainy season. At Leh they average 12°·1 in the former season and 12°·2 in the months corresponding to the rainy season in India.

Table XII indicates that the differences are least at 7 P.M. and increase to 4 A.M. or 5 A.M. These stations are all situated in the dry interior and obey the same law as the plain stations in the interior of the Peninsula, *viz.*, that the radiation increases in amount to a moderate extent during the night and has its maximum value about 1½ hours before sunrise and its minimum shortly after sunset. It should be carefully noted that the inverse law, *viz.*, that the differences decrease during the night hours obtains at stations in the interior of Extra-Tropical India, including Assam.

Table XIII gives the mean difference and the maximum and minimum values and epochs for each of the two chief seasons of the year.

The three following tables give monthly data for 24 stations for reference:—

TABLE XIV.—*Mean hourly differences between the temperature of the air and the temperature indicated by the grass radiation thermometer for mean night hours of the year (7 P.M. to 5 A.M.) at 24 stations in India.*

	Station.	7 P.M.	8 P.M.	9 P.M.	10 P.M.	11 P.M.	Mid-night.	1 A.M.	2 A.M.	3 A.M.	4 A.M.	5 A.M.
		°	°	°	°	°	°	°	°	°	°	°
Interior of Northern and Central India.	Patna	4·6	4·5	4·5	4·4	4·3	4·2	4·3	4·3	4·3	4·3	4·4
	Hazaribagh	8·0	8·4	8·4	8·4	8·3	8·2	8·3	8·2	8·2	8·1	8·0
	Allahabad	8·4	8·4	8·4	8·2	8·2	8·1	8·0	8·0	7·8	7·7	7·6
	Lucknow	?	7·3	7·3	7·1	7·1	7·1	7·2	7·3	7·2	7·1	7·0
	Agra	7·9	8·5	8·6	8·6	8·7	8·8	8·9	9·0	9·1	9·1	9·0
	Roorkee	6·8	6·7	6·7	6·7	6·7	6·6	6·5	6·5	6·5	6·4	6·3
	Lahore	?	7·4	7·3	7·1	7·0	6·9	7·0	7·0	6·9	6·7	6·6
	Deesa	8·6	8·4	8·3	8·1	7·8	7·6	7·6	7·6	7·6	7·7	7·4
	Jaipur	8·1	8·3	8·4	8·3	8·2	8·2	8·2	8·2	8·3	8·3	8·2
	Jubbulpore	6·9	6·8	6·7	6·7	6·6	6·4	6·6	6·7	6·7	6·8	6·9
Interior of the Peninsula.	Nagpur	10·4	10·8	10·8	10·9	10·9	10·8	10·8	10·7	10·7	10·7	10·6
	Poona	5·0	6·1	6·8	7·3	7·8	8·0	8·0	8·1	8·3	8·5	8·4
	Belgaum	4·5	4·6	4·9	5·1	5·1	5·4	5·7	5·7	5·9	6·2	6·0
	Bellary	1·6	1·7	1·7	1·7	3·1	3·4	3·7	3·9	4·1	4·1	4·2
	Trichinopoly	0·7	0·8	0·8	0·9	1·5	1·7	2·1	2·2	2·4	2·6	2·7
Coast Stations.	Rangoon	4·2	4·2	4·3	4·3	4·2	4·2	4·4	4·3	4·3	4·3	4·3
	Chittagong	5·7	5·9	5·9	5·9	5·8	5·5	5·4	5·2	5·0	4·0	4·9
	Kurrachee	4·7	5·3	5·8	6·0	5·9	5·9	5·8	5·8	5·9	5·8	5·8
	Aden	3·3	3·6	3·8	3·8	4·0	4·1	3·9	3·8	3·9	4·0	3·9
	Dhubri	6·1	6·2	6·1	6·0	5·8	5·7	5·6	5·5	5·3	5·3	5·2
	Sibsagar	5·9	5·4	5·1	4·7	4·4	4·1	4·1	4·0	3·9	3·8	3·8
Hill Stations.	Pachmarhi	8·0	8·6	9·0	9·3	9·4	9·5	9·9	10·1	10·2	10·4	10·5
	Leh	10·6	11·6	11·9	11·9	12·0	12·0	12·3	12·6	12·8	12·9	13·0
	Simla	8·5	8·6	8·9	9·2	9·4	9·7	9·9	10·1	10·0	10·1	10·0

TABLE XV.—*Mean hourly differences between the temperature of air and the temperature indicated by the grass radiation thermometer for mean night hours of the dry season, October to May, at 24 stations in India.*

	Station.	7 P.M.	8 P.M.	9 P.M.	10 P.M.	11 P.M.	Mid-night.	1 A.M.	2 A.M.	3 A.M.	4 A.M.	5 A.M.
		°	°	°	°	°	°	°	°	°	°	°
Interior of Northern and Central India.	Patna	5·9	5·5	5·4	5·3	5·3	5·1	5·1	5·2	5·2	5·2	5·2
	Hazaribagh	10·2	10·8	10·8	10·8	10·9	10·7	10·8	1·07	10·7	10·6	10·4
	Allahabad	10·9	10·9	10·9	10·7	10·5	10·5	10·4	10·3	10·0	10·0	10·0
	Lucknow	9·0	9·1	9·1	8·8	8·8	8·8	9·1	9·2	9·1	9·0	8·9
	Agra	9·9	10·5	10·4	10·5	10·5	10·6	10·8	10·9	10·9	11·0	10·8
	Roorkee	8·6	8·5	8·5	8·5	8·4	8·3	8·1	8·1	8·0	7·8	7·8
	Lahore	8·8	8·8	8·6	8·4	8·2	8·1	8·2	8·2	8·0	7·7	7·5
	Deesa	11·1	10·9	10·7	10·4	10·0	9·8	9·8	9·7	9·7	9·6	9·4
	Jaipur	10·5	10·5	10·5	10·3	10·2	10·2	10·1	10·0	10·2	10·1	10·1
	Jubbulpore	8·8	8·9	8·7	8·7	8·4	8·2	8·4	8·5	8·5	8·5	8·6
Interior of the Peninsula.	Nagpur	13·3	13·8	13·7	13·9	13·9	13·8	13·8	13·6	13·7	13·5	13·4
	Poona	6·4	7·8	8·8	9·4	10·1	10·4	10·5	10·6	10·8	11·0	10·9
	Belgaum	6 2	6·3	6·7	7·0	7·2	7·5	7·8	7·8	8·1	8·4	8·3
	Bellary	1·5	1·5	1·5	1·5	3·3	3·6	4·2	4·4	4·6	4·6	4·7
	Trichinopoly	0·7	0·8	0·8	0·9	1·7	1·9	2·3	2·5	2·7	2·9	3·0
Coast Stations.	Rangoon	5·3	5·3	5·3	5·3	5·2	5·2	5·4	5·4	5·4	5·3	5·2
	Chittagong	6 8	7·1	7·1	7·1	6·9	6·6	6·3	6·1	5·8	5·7	5·7
	Kurrachee	6·3	7·1	7·7	7·9	7·8	7·8	7·5	7·6	7·7	7·4	7·4
	Aden	3·5	3·6	3·8	3·8	3·9	3·9	3·7	3·6	3·8	3·9	3·9
	Dhubri	7·9	7·9	7·7	7·7	7·3	7·1	7·0	6·9	6·7	6·7	6·5
	Sibsagar	6·5	6·1	5·6	5·2	4·9	4·5	4·5	4·3	4·2	4·2	4·1
Hill Stations.	Pachmarhi	10·4	11·1	11·5	11·9	12·1	12·1	12·8	13·0	13·2	13·4	13·6
	Leh	10·4	11·2	11·7	11·8	12·0	12·0	12·3	12·6	12·8	13·1	13·2
	Simla	9·0	9·1	9·3	9·7	9·8	10·1	10·3	10·6	10·4	10·5	10·6

TABLE XVI.—*Mean hourly differences between the temperature of the air and the temperature indicated by the grass radiation thermometer for mean night hours of the wet season, June to September, at 24 stations in India.*

	Station.	7 P.M.	8 P.M.	9 P.M.	10 P.M.	11 P.M.	Mid-night.	1 A.M.	2 A.M.	3 A.M.	4 A.M.	5 A.M.
		°	°	°	°	°	°	°	°	°	°	°
Interior of Northern and Central India.	Patna	2·8	2·7	2·6	2·5	2·5	2·5	2·6	2·6	2·7	2·7	2·7
	Hazaribagh	3·5	3·6	3·5	3·6	3·4	3·4	3·3	3·2	3·2	3·2	3·2
	Allahabad	3·4	3·4	3·4	3·3	3·3	3·3	3·3	3·3	3·2	3·2	3·1
	Lucknow	?	3·8	3·8	3·8	3·5	3·6	3·4	3·5	3·5	3·4	3·3
	Agra	4·0	4·6	5·0	4·8	4·9	5·0	5·2	5·3	5·4	5·5	5·6
	Roorkee	3·0	3·1	3·2	3·1	3·3	3·3	3·3	3·4	3·4	3·5	3·4
	Lahore	?	4·6	4·7	4·7	4·7	4·6	4·6	4·7	4·7	4·6	4·7
	Deesa	3·5	3·6	3·4	3·4	3·3	3·2	3·3	3·4	3·4	3·5	3·3
	Jaipur	3·2	3·9	4·2	4·2	4·3	4·4	4·4	4·4	4·5	4·6	4·5
	Jubbulpore	3·0	2·9	2·8	2·8	2·8	2·8	2·9	3·0	3·1	3·3	3·4

TABLE XVI.—*Mean hourly differences between the temperature of the air and the temperature indicated by the grass radiation thermometer for mean night hours of the wet season, June to September, at 24 stations in India*—concld.

	Station.	7 P.M.	8 P.M.	9 P.M.	10 P.M.	11 P.M.	Mid-night.	1 A.M.	2 A.M.	3 A.M.	4 A.M.	5 A.M.
		°	°	°	°	°	°	°	°	°	°	°
Interior of the Peninsula.	Nagpur	4·6	4·9	5·0	5·1	5·0	4·9	4·9	4·8	4·9	5·0	5·1
	Poona	2·1	2·7	2·8	3·0	3·2	3·2	3·2	3·2	3·3	3·6	3·4
	Belgaum	1·1	1·1	1·2	1·3	1·2	1·3	1·4	1·6	1·6	1·8	1·6
	Bellary	1·9	2·0	2·0	2·0	2·7	2·8	2·9	3·0	3·1	3·2	3·3
	Trichinopoly	0·8	0·9	0·9	1·0	1·3	1·4	1·6	1·7	1·9	2·0	2·1
Coast Stations.	Rangoon	2·1	2·1	2·3	2·3	2·4	3·4	2·3	2·3	2·3	2·2	2·3
	Chittagong	3·4	3·5	3·5	3·6	3·5	3·5	3·5	3·5	3·4	3·4	3·3
	Kurrachee	1·3	1·7	2·0	2·1	2·2	2·2	2·2	2·2	2·5	2·6	2·7
	Aden	2·9	3·5	3·8	3·9	4·1	4·4	4·5	4·1	4·2	4·2	3·8
	Dhubri	2·4	2·8	2·9	2·8	2·8	2·8	2·7	2·5	2·5	2·6	2·6
	Sibsagar	4·6	4·2	3·9	3·7	3·4	3·3	3·3	3·2	3·2	3·0	3·1
Hill Stations.	Pachmarhi	3·2	3·6	4·0	4·1	4·2	4·1	4·3	4·3	4·2	4·3	4·3
	Leh	11·0	12·2	12·4	12·1	12·0	12·1	12·5	12·5	12·7	12·7	12·5
	Simla	6·5	6·8	7·6	7·4	8·0	7·8	8·2	8·3	8·5	8·3	7·7

An examination of the whole of the data of Tables II to XVI suggests the following inferences respecting this element of observation. For the sake of brevity the differences between the temperatures indicated by the grass radiation thermometer and the dry bulb or standard thermometer in the shade are termed surface radiation residuals or radiation differences:—

(1) The surface radiation residuals vary very slightly from place to place during the dry season in the interior of India (omitting the data of the doubtful stations of Trichinopoly, Bellary, and Lucknow). The grass radiation thermometers used in these observatories were ordinary minimum thermometers placed on pads covered with thick non-conducting material (usually coarse flannel) upon the ground and exposed freely to the sky. The grass radiation thermometers, when exposed in this manner, assume temperatures lower than those of the minimum thermometers in the shade. This is, of course, due to the fact that while both thermometers at night give up heat to the surrounding air, the grass radiation thermometers radiate heat into space and at the same time receive practically no heat from the ground. They hence record a temperature considerably lower than the temperature of the air and slightly lower than the ground temperature. The differences between the readings of the grass radiation thermometer and ordinary thermometer in the shade are usually assumed to be approximate relative measures of the radiation from surfaces at and near the earth. If this be the case the differences between the grass radiation and air in shade thermometers are approximate measures of the amount of heat conducted upwards from bodies at and near the earth's surface and increasing the temperature of the air or radiated into space.

The following gives means for the stations of Lahore, Roorkee, Agra, Allahabad,

Jaipur, Jubbulpore, Nagpur and Hazaribagh, stations which are outside of the action of any sea winds blowing across the Bay or the West Coast during the whole period of the dry monsoon:—

TABLE XVII.—*Mean difference of the shaded thermometer and the nocturnal radiation thermometer (7 P.M. to 5 A.M.).*

STATION.	November.	December.	January.	February.	March.	April.	May.	Absolute highest and lowest differences during period November to May. Maximum.	Month.	Hour.	Minimum.	Month.	Hour.
	°	°	°	°	°	°	°	°			°		
Lahore . . .	10·0	8·4	8·6	7·3	8·0	7·4	7·2	10·5	Nov.	19 & 20	5·9	May	5
Roorkee . .	9·6	8·7	8·2	7·7	8·2	8·7	6·3	10·6	„	18	5·7	„	19 & 20
Agra . . .	10·9	11·2	11·2	10·9	11·5	11·1	8·9	12·4	„	7	7·5	„	19
Allahabad . .	11·3	11·5	11·2	11·0	11·7	11·1	7·6	13·3	Apl.	19	4·1	„	6
Jaipur . . .	11·9	11·5	10·0	10·2	10·4	10·0	7·7	12·8	Nov.	19	4·1	„	6
Jubbulpore . .	9·0	8·6	8·7	9·1	9·7	9·4	7·7	10·1	Apl.	5	7·3	„	0 & 1
Nagpur. . .	14·1	15·5	14·5	13·8	14·0	14·2	12·6	16·1	Dec.	19	11·1	March May	18 19
Hazaribagh . . .	11·0	11·7	11·9	12·1	11·5	10·8	7·7	12·3	Jan. Feb.	2	4·0	May	18
Mean .	11·0	10·9	10·5	10·3	10·6	10·3	8·2						
Mean maximum difference.	11·6	11·6	11·2	10·9	11·1	11·2	8·9						
Mean minimum difference.	10·5	10·3	9·9	9·6	10·0	9·4	7·3						

The differences vary to some extent, due in part at least to slight differences of exposure with respect to the neighbouring native bazars.

The mean difference for these stations for the period is 10° which is also very approximately the difference for Jaipur. The mean difference between the ground temperature and the air temperature for the same diurnal period and period of the year at Jaipur is 6° nearly. The difference between these two quantities, *viz.*, 4°, probably represents the conduction of heat upwards through the earth's surface during the night hours.

(2) The radiation differences at the stations in the coast districts during the year are considerably smaller in amount than for the stations in the interior. They also differ considerably during the season and are largest in December and January and decrease from February to May with the increasing influence of the local sea winds of the period. They average 6°·5 in the cold weather and 4°·5 in the hot weather.

(3) The radiation differences during the rainy season are practically the same in amount over nearly the whole area in which the monsoon humid currents obtain in full strength during the period. They average 3° in the coast districts and 3° to 4° over the whole of the interior, excepting Upper India where they range between 4° and 5°. The differences between the dry bulb thermometer and surface thermometer readings (as given by the Jaipur data) average about 2°. This difference of 2° hence probably represents (or is a relative measure of) the amount of heat conducted upwards as heat through the earth's surface in the rainy season at Jaipur. It is barely half of the corresponding amount

for the dry weather, *viz.*, 4°. It hence follows that at least half of the amount of heat conducted upwards through the surface stratum in the rainy season is spent in the work of evaporation, and the remaining half passes outwards raising the surface temperature, and hence to a slight extent the temperature of the neighbouring air masses.

(4) It is also noteworthy that the radiation differences are fairly constant in amount during the period of general prevalence of the rains from the 15th June to the 15th September.

(5) As already noted the radiation differences are slightly greater in the cold than in the hot weather in the interior of India. This is probably due to the combination of decreased cloud amount and dust and decreased quantity of aqueous vapour in the night hours during the former as compared with the latter season.

(7) The radiation differences decrease slightly in amount during the night hours from 8 P. M. to 5 A. M. throughout the dry season at the following stations in the interior of Northern and Central India :—

Allahabad.	Jubbulpore.
Roorkee.	Chittagong.
Lahore.	Dhubri.
Deesa.	Sibsagar.
Jaipur.	

This is apparently due to slight increase of cloud in the early hours. The decrease is very marked at Chittagong, Sibsagar and Dhubri, where there is usually a considerable amount of cloud in the early morning hours (*vide* cloud curves, Fig. 1 in Plate XLII and Figs. 25 and 21 in Plate XLI).

The differences are practically constant throughout the night at Hazaribagh, Patna, Jaipur, Lucknow, Nagpur and Rangoon.

(8) The radiation differences increase slightly to considerably during the night hours in the dry season at the coast stations and stations in the interior of the Peninsula, and also at the hill stations in the Himalayas. The following table (XVIII) gives data in illustration :—

TABLE XVIII.

STATION.	DRY SEASON. 7 P.M. TO 5 A.M. Maximum during night.	Epoch.	Minimum during night.	Epoch.
	°		°	
Poona	11·5	4 A.M.	6·6	7 P.M.
Belgaum	9·0	4 „	6·7	7 & 8 „
Trichinopoly	3·1	5 „	0·6	7 „
Bellary	4·9	5 „	1·4	7 & 8 „

TABLE XVIII—*concld.*

Station.	Dry Season. 7 P.M. to 5 A.M. Maximum during night.	Epoch.	Minimum during night.	Epoch.
	°		°	
Kurrachee	7·9	10 P.M.	6·3	7 P.M.
Aden	3·9	11 P.M. to midnight 4 & 5 A.M.	3·5	7 "
Pachmarhi	13·6	5 A.M.	10·4	7 "
Simla	10·6	2 & 5 "	9·0	7 "
Leh	13·2	5 "	10·4	7 "

(9) At the great majority of stations in the interior the differences increase slightly during the night hours in the wet season due to decrease in the amount of cloud and also in small part to decrease in the strength of the winds. The following gives comparative data for these stations:—

TABLE XIX.

Station.	Wet or Rainy Season. 7 P.M. to 5 A.M. Maximum during night.	Minimum during night.	Difference.	Time of maximum epoch.	Time of minimum epoch.
	°	°	°		
Sibsagar	4·6	3·0	1·6	7 P.M.	4 A.M.
Roorkee	3·5	3·0	0·5	4 A.M.	7 P.M.
Jaipur	4·6	3·2	1·4	4 "	7 "
Jubbulpore	3·4	2·8	0·6	5 "	9 P.M. to midnight.
Poona	3·6	2·1	1·5	4 "	7 P.M.
Belgaum	1·8	1·1	0·7	4 "	7 & 8 "
Kurrachee	2·7	1·3	1·4	5 "	7 "
Aden	4·5	2·9	1·6	1 "	7 "
Pachmarhi	4·3	3·2	1·1	4 & 5 "	7 "
Simla	8·5	6·5	2·0	3 "	7 "
Leh	12·7	11·0	1·7	3 & 4 "	7 "

At the coast stations, including Deesa, Rangoon and Chittagong and also at Allahabad, Hazaribagh and Dhubri the differences are practically constant during the night.

(10) The radiation differences are practically constant at the coast stations during the night, whereas at the interior Peninsular stations and at the hill stations there is a marked increase. At the Peninsular stations, it is evidently due to the strong land influence in the air movement which gives decreasing cloud and decreasing amount of aqueous vapour over a considerable depth of the atmosphere. At the hill stations it is due to the increased flow from the hills to the plains in the lower strata which accompanies remarkable clearness of the atmosphere and freedom from cloud.

(11) The nocturnal variation of the radiation differences is small in amount during the rainy season at stations on and near the sea coast and in Assam, excepting Sibsagar, where the differences decrease considerably during the night.

The following gives data in illustration for Sibsagar:—

TABLE XX.

Station.	Rainy season. 7 P.M. to 5 A.M.				
	Maximum during night.	Minimum during night.	Difference.	Maximum epoch.	Minimum epoch.
	°	°	°		
Sibsagar	4·6	3·0	1·6	7 P.M.	4 A.M.

Comparative data of cloud, aqueous vapour pressure, humidity and grass radiation differences.—The following table gives comparative data of mean cloud amount, mean aqueous vapour, mean relative humidity and depression of the nocturnal radiation thermometer for the dry and wet seasons at 2[illegible] stations in India:—

TABLE XXI.

Station.	*Season.	Mean from 7 P.M. to 5 A.M. of			
		Depression of grass radiation thermometer.	Cloud amount.	Aqueous vapour pressure.	Relative humidity.
		°		"	%
Sibsagar	Dry season	5·0	6·07	·550	93·1
	Wet "	3·4	8·59	·941	91·7
Goalpara	Dry "	3·9	2·00	·521	74·9
	Wet "	2·2	5·94	·905	90·8
Patna	Dry "	5·4	1·96	·438	64·8
	Wet "	2·4	7·20	·954	87·3
Hazaribagh	Dry "	11·0	1·77	·331	52·0
	Wet "	3·1	7·87	·797	89·5

* Dry season, November to May. Wet season, July to September.

TABLE XXI—*contd.*

Station.	Season.*	Mean from 7 P.M. to 5 A.M. of: Depression of grass radiation thermometer.	Cloud amount.	Aqueous vapour pressure.	Relative humidity.
		°		"	%
Dhubri	Dry season	7·3	2·07	·559	82·4
	Wet „	2·7	6·20	·932	91·8
Roorkee	Dry „	8·2	2·19	·344	65·5
	Wet „	3·2	5·17	·867	86·2
Allahabad	Dry „	10·8	1·09	·397	65·3
	Wet „	3·1	5·40	·923	87·0
Lucknow	Dry „	9·0	1·44	·367	61·8
	Wet „	3·2	5·20	·883	83·1
Agra	Dry „	10·8	1·46	·351	53·0
	Wet „	4·6	4·67	·862	78·3
Lahore	Dry „	8·1	2·07	·333	62·8
	Wet „	4·3	2·87	·817	72·8
Deesa	Dry „	10·1	0·97	·309	40·5
	Wet „	3·3	6·37	·787	79·5
Kurrachee	Dry „	7·6	1·37	·533	70·4
	Wet „	2·1	5·70	·872	85·0
Cuttack	Dry „	10·3	2·07	·651	76·2
	Wet „	5·1	5·73	·895	84·7
Jubbulpore	Dry „	8·9	1·70	·350	56·0
	Wet „	2·9	6·93	·785	86·2
Pachmarhi	Dry „	12·6	1·67	·285	52·8
	Wet „	4·0	7·63	·647	89·4
Nagpur	Dry „	14·1	2·07	·372	48·6
	Wet „	4·9	7·39	·797	86·3
Poona	Dry „	10·2	1·37	·391	54·8
	Wet „	2·8	7·83	·674	87·8
Belgaum	Dry „	8·0	1·47	·477	70·1
	Wet „	1·2	7·45	·645	95·0
Chittagong	Dry „	6·7	2·43	·651	83·9
	Wet „	3·5	7·80	·912	91·7

* Dry season, November to May. Wet season, July to September.

TABLE XXI—*concld.*

Station.	Season.*	Mean from 7 P.M. to 5 A.M. of			
		Depression of grass radiation thermometer.	Cloud amount.	Aqueous vapour pressure.	Relative humidity.
		°		"	%
Rangoon	Dry Season	5·5	1·69	·731	85·4
	Wet "	2·3	7·50	·893	96·1
Jaipur	Dry "	10·2	1·76	·313	50·7
	Wet "	4·1	5·38	·785	80·5
Leh	Dry "	11·6	4·80	·085	60·1
	Wet "	12·2	3·66	·206	51·3

* Dry season, November to May. Wet season, July to September.

The preceding comparative data indicate that the grass radiation residuals decrease in amount with increase of cloud, and of aqueous vapour pressure. It is not possible to obtain a simple formula for the law of variation. A very rough approximation is that the differences vary inversely as the square root of the product of the amount of cloud and the aqueous vapour pressure.

CHAPTER III.

THE TEMPERATURE OF THE GROUND.

The temperature of the ground at varying depths up to 30 feet is recorded at five stations in India, *viz.*, Alipore (Calcutta), Allahabad, Dehra Dun, Lahore, and Jaipur. The only important observations under this section are those of the temperature of the ground surface. Observations are recorded once or twice a day at Allahabad, Calcutta (Alipore), Jaipur and Lahore. They, however, throw little or no light on the diurnal variation of the surface temperature. The only observations available are a series of hourly observations at Jaipur in the year 1885 and a series of two hourly observations at Allahabad in 1900. The following gives a brief discussion of these important observations.

Diurnal variation of the surface temperature, Jaipur.—Hourly observations of this element were taken at Jaipur in the year 1885. The soil in the observatory compound is, as over a large part of Rajputana, sandy. It is never watered artificially. The means of the temperature data recorded hence probably represent closely the variation of the surface temperature in the open over the greater part of North-Western India where the soil is more or less of a sandy texture.

The following table gives mean data for the months of December and May, the first representative of the cold weather, and the second of the hot weather (in its most intense form). The data include the hourly values of the air temperature 4 feet above the ground, of the temperature of the ground surface, the variations of each from the mean of the day, the hourly differences between the air and surface temperatures and also the rate of change of temperature per hour of the air and of the earth's surface. The data are plotted in figures 1 to 7, Plate VIII.

TABLE XXII.—*Jaipur.*

HOUR.	DECEMBER 1885.							MAY 1885.						
	AIR TEMPERATURE.			SURFACE TEMPERATURE.			Surface minus air temperature.	AIR TEMPERATURE.			SURFACE TEMPERATURE.			Surface-minus air temperature.
	Actual.	Variation from mean of day.	Rate of change.	Actual.	Variation from mean of day.	Rate of change.		Actual.	Variation from mean of day.	Rate of change.	Actual.	Variation from mean of day.	Rate of change.	
	°	°	°	°	°	°	°	°	°	°	°	°	°	°
Midnight	52·6	—6·3	—0·8	46·5	—13·2	—1·2	—6·1	78·6	—7·0	—0·8	73·3	—22·3	—0·3	—5·3
1	52·4	—6·5	—0·2	46·0	—13·7	—0·5	—6·4	77·2	—8·4	—1·4	72·0	—23·6	—1·3	—5·2
2	51·7	—7·2	—0·7	44·3	—15·4	—1·7	—7·4	76·8	—8·8	—0·4	72·1	—23·5	+0·1	—4·7
3	50·8	—8·1	—0·9	43·3	—16·4	—1·0	—7·5	76·4	—9·2	—0·4	71·0	—24·6	—1·1	—5·4
4	50·4	—8·5	—0·4	42·4	—17·3	—0·9	—8·0	76·0	—9·6	—0·4	70·4	—25·2	—0·6	—5·6
5	49·1	—9·8	—1·3	42·2	—17·5	—0·2	—6·9	74·6	—11·0	—1·4	69·4	—26·2	—1·0	—5·7
6	49·0	—9·9	—0·1	41·9	—17·8	—0·3	—7·1	74·5	—11·1	—0·1	69·7	—25·9	+0·3	—4·8
7	49·1	—9·8	+0·1	41·8	—17·9	—0·1	—7·3	79·4	—6·2	+4·9	81·4	—14·2	+11·7	+2·0
8	54·6	—4·3	+5·5	51·5	— 8·2	+9·7	—3·1	84·5	—1·1	+5·1	98·1	+2·5	+16·7	+13·6
9	61·4	+2·5	+6·8	62·9	+ 3·2	+11·4	+1·5	86·7	+1·1	+2·2	110·0	+14·4	+11·9	+23·3

TABLE XXII.—*Jaipur*—concld.

Hour.	December 1885.							May 1885.						
	Air temperature.			Surface temperature.			Surface minus air temperature.	Air temperature.			Surface temperature.			Surface minus air temperature.
	Actual.	Variation from mean of day.	Rate of change.	Actual.	Variation from mean of day.	Rate of change.		Actual.	Variation from mean of day.	Rate of change.	Actual.	Variation from mean of day.	Rate of change.	
	°	°	°	°	°	°	°	°	°	°	°	°	°	°
10	65·0	+6·1	+3·6	72·9	+13·2	+10·0	+7·9	90·2	+4·6	+3·5	121·0	+25·4	+11·0	+30·8
11	67·7	+8·8	+2·7	83·4	+23·7	+10·5	+15·7	92·9	+7·3	+2·7	127·8	+32·2	+6·8	+34·9
Noon	69·7	+10·8	+2·0	87·9	+28·2	+4·5	+18·2	95·3	+9·7	+2·4	135·1	+39·5	+7·3	+39·8
13	70·3	+11·4	+0·6	90·1	+30·4	+2·2	+19·8	98·3	+12·7	+3·0	141·2	+45·6	+6·1	+42·9
14	71·5	+12·6	+1·2	89·1	+29·4	−1·0	+17·6	97·4	+11·8	−0·9	137·7	+42·1	−3·5	+40·3
15	71·7	+12·8	+0·2	87·6	+27·9	−1·5	+15·9	97·4	+11·8	0	129·1	+33·5	−8·6	+31·7
16	70·3	+11·4	−1·4	78·6	+18·9	−9·0	+8·3	95·6	+10·0	−1·8	115·2	+19·6	−13·9	+19·6
17	66·3	+7·4	−4·0	66·1	+6·4	−12·5	−0·2	94·3	+8·7	−1·3	104·2	+8·6	−11·0	+9·9
18	61·9	+3·0	−4·4	59·2	−0·5	−6·9	−2·7	90·8	+5·2	−3·5	96·3	+0·7	−7·9	+5·5
19	58·9	0	−3·0	54·9	−4·8	−4·3	−4·0	87·7	+2·1	−3·1	87·4	−8·2	−8·9	−0·3
20	57·4	−1·5	−1·5	52·9	−6·8	−2·0	−4·5	85·7	+0·1	−2·0	82·8	−12·8	−4·6	−2·9
21	55·4	−3·5	−2·0	51·1	−8·6	−1·8	−4·3	84·3	−1·3	−1·4	80·3	−15·3	−2·5	−4·0
22	53·7	−5·2	−1·7	49·5	−10·2	−1·6	−4·2	81·0	−4·6	−3·3	76·4	−19·2	−3·9	−4·6
23	53·4	−5·5	−0·3	47·7	−12·0	−1·8	−5·7	79·4	−6·2	−1·6	73·6	−22·0	−2·8	−5·8
Mean	58·9	...	...	59·7	...	...	+0·8	85·6	...	...	95·6	...	...	+16·0

The following are the more important inferences from the data of the preceding table :—

(1) In the month of December, representative of the cold weather, the temperature of the ground surface is below that of the air, 4 feet above, from 5 P.M. to 8-40 A.M., that is for $15\frac{2}{3}$ hours of the 24 hours period. The differences between the two temperatures during the night period of lower surface temperature increase from 5 P.M. to 2 A.M. and are nearly constant until 7 A.M. The temperature of the ground is very approximately constant from 4 A.M. to 7 A.M. and of the air from 5 A.M. to 7 A.M.

(2) In December the ground temperature is above the air temperature from 8-40 A.M. to 5 P.M., that is for $8\frac{1}{3}$ hours or practically for one-third of the day only. The ground surface attains its maximum temperature at 1-10 P.M. or about $1\frac{1}{4}$ hours after the maximum elevation of the sun, but about an hour and a half before the epoch of the maximum of the air temperature. The changes of temperature, both of the air and ground surface, are very slight from noon to 2 P.M., and hence the mean differences of observations taken at any instant during this period gives an approximate estimate of the maximum difference.

(3) The day portion of the curve representing the variation of the ground temperature in December is much more symmetrical than that of the air temperature, and is as symmetrical as that of the corresponding solar radiation curve.

It is noteworthy that the mean temperature of the surface in December is practically identical with that of the air 4 feet above at 9 A.M. and 5 P.M.

(4) The temperature of the ground in the month of May, representative of the hot weather, is lower than that of the air 4 feet above from 7 P.M. to 6-45 A.M. or for $11\frac{3}{4}$ hours. The difference is nearly constant in amount from 10 P.M. to 6 A.M. ranging between $4^\circ\cdot6$ and $5^\circ\cdot8$.

The night differences of the period are slightly less in this month than in the month of December.

(5) The temperature of the ground in May is higher than that of the air 4 feet above on the average for $12\frac{1}{4}$ hours daily, *viz.*, from 6-45 A.M. to about 7 P.M. The differences have their maximum value at about 1-15 P.M., when it averages $43^\circ\cdot7$. Its actual value for 1 P.M. is $42^\circ\cdot9$, which is about two times the maximum difference in January ($21^\circ\cdot7$).

(6) The curve representing the diurnal variation of the day hours in May is symmetrical, the chief difference in form between that curve and the curve representing the intensity of solar radiation being a retard of about one hour in the maximum epoch of the former. As the difference between the ground surface and the air temperature is probably an approximate measure of the action giving rise to convective movements, measurement of the positive areas for the differences show that it is at least three times as great in May as in December at Jaipur.

Annual Variation of the surface temperature, Jaipur.—The annual variation may be considered from several points of view. The most interesting of these are, first, the variation of the mean daily temperature of the surface soil; secondly, the variation of the mean maximum temperature of the surface soil; and thirdly, the variation of the maximum differences between the air and ground temperature. Monthly means of these data for the term days of the year 1885 are given in the following table, in the preparation of which it was assumed that a fairly accurate estimate of the maximum differences are obtaining by taking the differences of the maxima of each (*viz.*, air and ground temperatures), although their epochs are not quite simultaneous :—

TABLE XXIII.

MONTH.	Mean temperature of the surface soil.	Mean temperature of air at 4 feet above ground.	Difference, surface and air mean temperature.	Mean maximum temperature of surface.	Mean maximum air temperature 4 feet above ground.	Difference, maximum ground and air temperatures.
	°	°	°	°	°	°
January	61·8	59·6	2·2	90·7	72·1	18·6
February	66·5	61·9	4·6	112·8	74·4	38·4
March	83·8	77·1	6·7	131·9	90·9	41·0
April	86·2	79·6	6·6	130·0	95·8	34·2
May	95·6	85·6	10·0	141·2	99·5	41·7
June	96·5	87·9	8·6	132·7	102·1	30·6
July	89·4	83·6	5·8	113·9	92·9	21·0

TABLE XXIII—*concld.*

Month.	Mean temperature of the surface soil.	Mean temperature of air at 4 feet above ground.	Difference, surface and air mean temperature.	Mean maximum temperature of surface.	Mean maximum air temperature 4 feet above ground.	Difference, maximum ground and air temperatures.
	°	°	°	°	°	°
August	83·9	79·6	4·3	101·4	88·1	13·3
September	90·3	81·7	8·6	131·3	95·0	36·3
October	84·5	78·3	6·2	130·3	95·2	35·1
November	70·6	69·5	1·1	115·3	87·6	27·7
December	59·7	58·9	0·8	90·1	74·7	15·4
MEAN	80·7	75·3	5·4	118·5	89·0	29·4

The data of the preceding table show that the mean maximum or midday difference between the temperature of the air in the shade four feet above the ground and the temperature of the ground, averaged 29°·4.

It may be noted that there was a large excess of cloud at Jaipur in the year 1885 during the months of January (+1·06), April (+1·03), May (+1·26), June (+1·17) and August (+1·21), whilst skies were unusually free from cloud in September (—2·29). The means for these months in 1885 in the preceding table hence probably differ to some extent from true normal means.

It is, taking these anomalies into consideration, probable that the maximum differences are least in December, when they average 15°, and that they increase rapidly in February and March, and probably average about 45° in clear weather in April and May. The greatest difference actually observed was 46°·8 on the 7th June 1885.

The maximum differences are moderate in amount during the height of the rains in July and August, when they probably average about 20°.

The data are interesting, as they furnish the only estimate at present for the actions giving rise to the ordinary convective air movement of the dry weather in India. That movement is undoubtedly due to the unequal heating of the earth's surface and to the large differences of temperature in the lowest stratum of the atmosphere in contact with and near the earth's surface. The great activity in the hot weather months is in part due to the greater length of the day period of higher surface than air temperature, but chiefly to the very large amount of these differences in the hottest period of the day.

Allahabad.—Observations at two-hourly intervals from 6 A.M. to 10 P.M. were recorded at Allahabad in May 1900, under the direction of Mr. Murray, Meteorological Reporter to the Government of the North-Western Provinces, chiefly with a view to determine the effect of differences of exposure of the surface thermometer. Two thermometers were exposed side by side, the bulb of one resting on the ground and of the other being slightly covered with soil. The observations showed there were only slight differences and hence indicate that the differences of exposure which probably obtain at the stations recording these observations do not appreciably modify the results of the ground temperature, observations recorded at several stations in India, and in part tabulated in the annual reports issued by the Department. These observations may hence be accepted as intercomparable.

The ground thermometer at Allahabad is exposed in an open space near the thermometer shed. The soil is alluvial, hardened in the dry weather by exposure to the sun, and partially covered with some grass, the dried remains of the growth of the wet season. In the south-west monsoon period, the ground is fairly saturated with moisture and supports a vigorous growth of grass which is cut down as it appears so as not to interfere with the observations. The observations fairly represent the character of the diurnal variation of the ground temperature during the hot weather in the alluvial tracts of the interior of India.

The following table gives mean data for May, representative of the hot weather. The values are plotted in figures 8 to 10, Plate VIII.

TABLE XXIV.—*Giving data of air temperature and ground surface temperature at Allahabad.*

Hour.	MAY 1900.													
	AIR TEMPERATURE.			SURFACE TEMPERATURE; BULB LIGHTLY COVERED.					SURFACE TEMPERATURE; BULB EXPOSED.					
	Actual.	Variation from mean.	Rate of change.	Actual.	Variation from mean.	Rate of change.	Surface minus air temperature.	Rate of change.	Actual.	Variation from mean of day.	Rate of change.	Surface minus air temperature.	Rate of change.
	°	°	°	°	°	°	°	°	°	°	°	°	°
6 A.M.	81·8	−10·1	...	80·5	−25·5	...	− 1·3	...	82·1	−24·3	...	+ 0·3	...
8 „	88·9	− 3·0	+7·1	101·9	+ 4·1	+21·4	+13·0	+14·3	101·8	− 4·6	+19·7	+12·9	+12·6
10 „	96·3	+ 4·4	+7·4	123·9	+17·9	+22·0	+27·6	+14·6	123·4	+17·0	+21·6	+27·1	+14·2
Noon	101·2	+ 9·3	+4·9	140·4	+34·4	+16·5	+39·2	+11·6	138·3	+31·9	+14·9	+37·1	+10·0
2 P.M.	103·0	+11·1	+1·8	139·5	+33·5	− 0·9	+36·5	− 2·7	137·5	+31·1	− 0·8	+34·5	− 2·6
4 „	102·6	+10·7	−0·6	123·6	+17·6	−15·9	+21·0	−15·5	123·1	+16·7	−14·4	+20·5	−14·0
6 „	98·5	+ 6·6	−4·1	103·4	− 2·6	−20·2	+ 4·9	−16·1	105·1	− 1·3	−18·0	+ 6·6	−13·9
8 „	92·2	+ 0·3	−6·3	92·0	−14·0	−11·4	− 0·2	− 5·1	94·4	−12·0	−10·7	+ 2·2	− 4·4
10 „	89·3	− 2·6	−2·9	87·0	−19·0	− 5·0	− 2·3	− 2·1	89·4	−17·0	− 5·0	+ 0·1	− 2·1
Mean of day	91·9	...	...	106·0	...	...	...	...	106·4	...	...	...	...

The data show that the readings of the surface thermometer when lightly covered with soil, were (from 8 A.M. to 4 P.M.) slightly higher than those of a similar thermometer, the bulb of which was exposed to the air, and were, on the other hand, slightly lower during the night and morning hours. The maximum differences did not exceed 2°·5 in either case.

Taking the data of the eighth figure column (which are most comparable with those for Jaipur, where the bulb of the instrument was very lightly covered with sandy soil) it will be seen that the figures for Allahabad agree very closely with the corresponding results obtained for the month of May 1885 at Jaipur. The ground thermometer at Allahabad in May 1900 was higher than the air thermometer from about 6-15 A.M. to 8 P.M. or for 13¾ hours. The mean maximum difference (at noon) averaged 39°·2 for the month. As in the case of Jaipur the curves representing the surface temperature at Allahabad are much more symmetrical than those of the air temperature. The curves giving surface temperature and surface minus air temperature for Allahabad agree very closely with the corresponding curves of Jaipur for the month of May 1885.

CHAPTER IV.

AIR TEMPERATURE.

The data discussed in the present chapter are the temperature sections in the series of memoirs of the hourly observations recorded at twenty-six stations in India in volumes V, IX and X of the Indian Meteorological Memoirs.

The variations of the temperature of the air at any given place may be divided into :—

(1) Regular or periodic :
- (*a*) Annual
- (*b*) Diurnal.
- (*c*) Secular (probably due directly or indirectly to long period variations in the intensity of solar radiation).

(2). Irregular.

The variations are the product directly or indirectly of the solar radiation. The intensity of the solar radiation at any given part of the earth's surface has an annual and also a diurnal periodicity, which are functions of the sun's actual distance and of his angular altitude. The annual variation is a continuous function of the variables on which it depends, whereas the diurnal variation is a discontinuous function due to the diurnal rotation of the earth about its polar axis.

The actual intensity of the solar radiation at any point of the earth's surface varies very largely and irregularly in amount, due to the action of the air, aqueous vapour, clouds, dust, etc. in absorbing the solar radiation in part during its passage through the atmosphere to the earth's surface. The percentage amount of the solar radiation which is absorbed in this manner (or the rate of absorption per unit thickness of dry air or of air containing invisible aqueous vapour) is comparatively small. According to Langley, about 30 per cent., on the average, of the solar radiation is absorbed in its passage through the whole depth of the atmosphere.

It is evident that whenever the heat, due to solar radiation, is absorbed by the air without being utilized for the work of evaporation, it increases either the total heat and temperature or the movement of the mass of air directly affected thereby.

It may hence be assumed that the amount of the solar radiation absorbed during its passage through the earth's atmosphere chiefly depends—

(1) Upon the thickness of the air column traversed by the solar rays and hence inversely upon the altitude of the sun.
(2) Upon the humidity of the atmosphere.
(3) Upon the amount of dust.
(4) Upon the amount, density and thickness of the clouds.

The amount of the sun's heat or solar radiation absorbed by the earth's surface varies greatly, as it is practically the residual amount left after absorption during its passage through the atmosphere. When the surface of the earth is dry, by far the greater part of this residual energy is absorbed as heat and raises the temperature of a thin stratum of the surface. If, on the other hand, the surface be moist as is the case after heavy rain, it is almost entirely utilized in the work of evaporating the water in the surface layers.

The temperature of the lowest stratum of the atmosphere, that is, of the air in the immediate neighbourhood of the earth, is undoubtedly mainly determined by the temperature of the earth's surface. The comparison of the hourly surface temperatures for

the year 1885 at Jaipur with the air temperature as registered in the shade at four feet above the earth's surface shows this in a most interesting manner. In figures 1 to 6, Plate IX, are given diurnal curves showing the mean temperature of the surface in January, April and July 1885 and the corresponding air temperature. In figures 7, 8 and 9, Plate IX, are also given curves showing the mean hourly differences of temperature of the surface soil and of the air at 4 feet above the surface.

An important factor in modifying the temperature of the air is the character of the prevailing winds. Very considerable changes may be produced by the alternation of land and sea-breezes and of up and down air movements in mountain districts.

It is hence evident that the factors determining the temperature of the air at a given place as observed under standard conditions are numerous and complex, and that it is not possible to determine mathematically *a priori* formulæ for the diurnal or annual variation at a given place.

It may also be pointed out that the temperature of the air at a given place is the temperature of a constantly changing mass of air, but it is probable that the conditions of the whole mass of air moving horizontally through a given spot are similar, and hence that the recorded temperatures represent the thermal conditions of the air generally in that neighbourhood as observed under the standard conditions.

In Plates XV to XXII are given curves representing the diurnal variation of temperature of the four seasons or periods of the year into which it has been divided for the purpose of this discussion at 28 stations in India. These periods are:

1st—The cold weather period, including the months of January and February, when cool dry weather with light land winds and clear skies generally prevails over nearly the whole of India. Cyclonic storms of large extent but of very slight intensity occasionally pass across Northern India and give light to moderate general rain. In the Peninsula fine weather prevails almost without interruption.

2nd—The hot weather period from March to May. The chief features of this period over the interior of India are the increasing dryness and temperature of the air which usually culminates in a period of intense heat and dryness of the air in North-Western India in the third or fourth week of May. Weather is frequently disturbed during this period by local storms, due to the intensity of the thermal actions. Thunderstorms are of frequent occurrence in North-Eastern India, Burma, Malabar and the hill districts of Northern India, and duststorms in the drier districts of Northern India, including the Punjab, Rajputana and the North-Western Provinces.

3rd—The rainy season or south-west monsoon proper. During this period winds of oceanic origin prevail generally in India and are usually opposite in direction to those which obtain in the cold weather. Rain is of frequent occurrence, the air is very damp and temperature is moderately high, but the diurnal range is small.

4th—The retreating south-west monsoon period. During this period the oceanic or sea current which has prevailed during the previous period gradually withdraws and fine clear weather with light land winds sets in, commencing in Upper India and gradually extending eastwards and southwards. North-Eastern India and Burma receive occasional

rain during the first half of this period, and the Peninsula, more especially the coast districts, moderate and general rain which is however very irregularly distributed and much more erratic and variable in its occurrence than the rainfall of the South-West Monsoon proper. Cyclonic storms, occasionally of great intensity, form in the Bay during this period and give more or less concentrated rain over the districts of the Peninsula which they traverse in their landward course.

The following is a list of the stations for which hourly observation data of temperature are available together with a statement of their position and elevation :—

Station.	Elevation of barometer cistern above mean sea level.	Latitude North.		Longitude East.		Class of observatory.
	Feet.	°	′	°	′	
Aden	94	12	45	45	3	2nd Class.
Agra	555	27	10	78	5	Do.
Allahabad	309	25	26	81	52	1st Class.
Belgaum	2,524	15	52	74	42	2nd Class.
Bellary	1,475	15	9	76	57	Do.
Bombay	37	18	54	72	49	1st Class.
Calcutta	21	22	32	88	20	Do.
Chittagong	87	22	21	91	50	2nd Class.
Cuttack	80	20	29	85	54	Do.
Deesa	466	24	16	72	14	Do.
Dhubri	115	26	7	89	50	Do.
Hazaribagh	2,007	24	0	85	24	Do.
Jaipur	1,431	26	55	75	50	1st Class.
Jubbulpore	1,327	23	9	79	59	2nd Class.
Kurrachee	49	24	47	67	4	Do.
Lahore	702	31	34	74	20	1st Class.
Leh (Hills)	11,503	34	10	77	42	2nd Class.
Lucknow	370	26	50	81	0	Do.
Madras	22	13	4	80	14	1st Class.
Nagpur	1,025	21	9	79	11	2nd Class.
Pachmarhi (Hills)	3,528	22	28	78	28	Do.
Patna	183	25	37	85	14	Do.
Poona	1,840	18	28	74	10	Do.
Rangoon	41	16	46	96	12	Do.
Roorkee	887	29	52	77	56	Do.
Sibsagar	333	26	59	94	40	Do.
Simla (Hills)	7,224	31	6	77	12	1st Class.
Trivandrum	198	8	30	77	0	Do.
Trichinopoly	255	10	50	78	44	2nd Class.

For the purposes of the discussion the stations are arranged into four groups according to the following classification:—

(1) Tropical Coast.
(2) Tropical Inland.
(3) Extra-Tropical Coast and Assam.
(4) Extra-Tropical Inland.

The following gives the arrangement of stations according to this classification :—

(1) Tropical Coast:

Trivandrum.	Bombay.
Madras.	Aden.

Rangoon.

(2) Tropical Inland:

Trichinopoly.	Poona.
Bellary.	Nagpur.
Belgaum.	Pachmarhi (Hills).

(3) Extra-Tropical Coast and Assam:

Chittagong.	Cuttack.
Calcutta.	Dhubri.
Kurrachee.	Sibsagar.

(4) Extra-Tropical Inland:

Patna.	Jaipur.
Hazaribagh.	Roorkee.
Allahabad.	Deesa.
Jubbulpore.	Lahore.
Lucknow.	Simla (Hills).
Agra.	Leh (Hills).

The temperature data furnished by the hourly observations at these stations (except Simla) are discussed under the following heads:—

A.—Annual variation:

(1) Epochs of maximum and minimum.
(2) Range or amplitude of variation.
(3) Law of variation with season.

B.—Diurnal variation:

(1) Annual variation.
(2) Seasonal variation.
(3) Epochs of maximum and minimum values.
(4) Amplitudes of variation.

C.—Comparison of the constants of the harmonic formula representing the diurnal variation with the corresponding constants for other elements of observation.

In the final discussion, Chapter IX, we are chiefly concerned with the facts of the annual and diurnal variations of temperature.

Annual variation of temperature.—In Table XXV are given the mean monthly temperatures for each month of the year and the mean annual temperature. These values are plotted in the curves of Plates X and XI which hence represent the march of the mean daily temperature as determined from monthly values throughout the year.

In Table XXVI are given the values of the mean monthly temperatures reduced to sea-level, the correction for elevation in India being assumed to be 1° for every 450 feet.

TABLE XXV—*Giving the mean monthly and annual temperatures at twenty-eight stations in India.*

AREA.	STATION.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Year.
		°	°	°	°	°	°	°	°	°	°	°	°	°
TROPICAL COAST.	Trivandrum	76·59	77·98	80·41	80·98	80·25	77·60	76·69	76·72	77·11	76·99	77·40	76·32	77·92
	Madras	75·10	76·70	80·00	84·00	86·70	86·40	84·50	83·30	83·00	80·60	77·50	75·50	81·10
	Bombay	73·80	75·50	79·10	82·60	85·20	83·30	81·10	80·20	80·20	81·30	79·10	76·20	79·80
	Aden	75·86	76·67	78·58	82·24	85·99	87·96	86·88	86·01	87·12	82·56	78·63	76·84	82·03
	Rangoon	74·42	76·86	81·06	84·71	82·49	79·38	78·46	78·52	78·85	79·75	78·32	75·46	78·97
TROPICAL INLAND.	Trichinopoly	76·17	78·93	83·93	88·11	87·79	86·71	85·42	84·11	83·67	80·93	78·30	76·37	82·55
	Bellary	73·09	79·28	85·48	89·20	88·83	83·18	80·72	80·49	80·32	78·94	75·03	72·49	80·56
	Belgaum	69·31	72·74	76·63	78·74	77·81	72·37	70·01	69·50	70·15	72·32	70·68	69·01	72·45
	Poona	69·31	73·25	79·51	84·26	83·71	78·39	74·70	73·63	74·14	75·66	72·03	68·42	75·51
	Nagpur	68·23	73·58	82·16	90·55	93·97	86·58	80·03	79·56	79·71	77·86	71·34	66·77	79·19
	Pachmarhi (Hills)	58·44	62·55	72·62	81·25	84·78	78·27	71·27	70·24	71·13	68·39	60·79	56·64	69·70
EXTRA-TROPICAL COAST AND ASSAM.	Chittagong	66·40	69·80	77·00	81·00	82·10	81·20	81·00	80·40	80·70	79·50	74·20	68·00	76·80
	Calcutta	65·10	69·10	78·80	85·10	85·20	84·70	83·00	82·40	82·40	79·80	72·00	65·10	77·80
	Kurrachee	65·18	67·61	75·18	79·77	84·54	86·55	84·14	82·09	81·68	79·88	73·89	67·31	77·32
	Cuttack	70·10	75·15	82·20	87·11	87·70	86·31	82·77	82·29	82·47	80·79	74·02	68·71	79·97
	Dhubri	62·30	64·60	74·20	78·80	78·60	79·80	81·90	81·00	79·50	77·90	70·80	64·30	74·50
	Sibsagar	57·70	60·90	67·50	73·20	77·40	81·90	83·00	82·50	80·80	76·60	67·50	59·90	72·40
EXTRA-TROPICAL INLAND.	Patna	60·60	65·10	77·10	86·10	88·10	87·50	84·20	83·60	83·50	79·20	69·80	62·50	77·30
	Hazaribagh	60·70	65·20	75·20	83·80	84·70	82·60	78·30	77·30	77·20	73·80	66·60	60·40	73·80
	Allahabad	60·11	64·46	76·97	87·51	91·76	91·27	84·74	83·27	83·07	78·07	68·14	60·37	77·48
	Jubbulpore	61·82	66·20	76·72	85·98	90·93	85·49	78·75	78·02	78·68	74·53	65·87	60·24	75·27
	Lucknow	58·53	63·31	75·07	85·95	89·78	90·82	85·32	83·62	82·96	76·58	65·97	58·60	76·35
	Agra	59·90	63·97	76·45	87·69	93·26	94·21	85·84	84·31	83·88	78·81	68·35	60·91	78·17
	Jaipur	59·58	63·25	74·43	85·06	90·64	89·93	83·25	81·11	81·43	77·23	67·57	61·00	76·21
	Roorkee	55·50	59·60	70·10	80·90	87·40	89·60	83·80	82·90	81·40	73·80	62·90	56·50	73·70
	Deesa	67·46	70·23	80·05	88·16	91·71	90·13	83·23	81·13	82·13	81·21	73·63	68·60	79·87
	Lahore	53·98	57·31	69·59	80·90	88·59	93·75	89·33	87·61	84·25	75·45	62·80	54·15	74·83
	Leh (Hills)	19·38	20·09	31·67	42·08	48·39	56·31	62·31	60·94	53·52	41·80	31·61	23·72	41·02

TABLE XXVI—*Giving the mean monthly and annual temperatures of the preceding table reduced to sea-level, the law of correction employed being 1° per 450 feet of elevation.*

AREA.	STATION.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Year.
		°	°	°	°	°	°	°	°	°	°	°	°	°
TROPICAL COAST.	Trivandrum	77·03	78·42	80·85	81·42	80·70	78·04	77·13	77·16	77·55	77·43	77·84	76·76	78·36
	Madras	75·15	76·75	80·05	84·05	86·75	86·45	84·55	83·35	83·05	80·65	77·55	75·55	81·15
	Bombay	73·88	75·58	79·18	82·68	85·28	83·38	81·18	80·28	80·28	81·38	79·18	76·28	79·88
	Aden	76·07	76·88	78·79	82·45	86·20	88·17	87·09	86·22	87·33	82·77	78·84	77·05	82·24
	Rangoon	74·51	76·95	81·15	84·80	82·58	79·47	78·55	78·61	78·94	79·84	78·41	75·55	79·06
TROPICAL INLAND.	Trichinopoly	76·74	79·50	84·50	88·68	88·36	87·28	85·99	84·68	84·24	81·50	78·06	76·94	83·12
	Bellary	76·37	82·56	88·76	92·48	92·11	86·46	84·00	83·77	83·60	82·22	78·31	75·77	83·84
	Belgaum	74·92	78·35	82·24	84·35	83·42	77·98	75·62	75·11	75·76	77·93	76·29	74·62	78·06
	Poona	73·40	77·34	83·60	88·35	87·80	82·48	78·79	77·72	78·23	79·75	76·12	72·51	79·60
	Nagpur	70·51	75·86	84·44	92·83	96·25	88·86	82·31	81·84	81·99	80·14	73·62	69·05	81·47
	Pachmarhi (Hills)	66·28	70·39	80·46	89·09	92·62	86·11	79·11	78·08	78·97	76·23	68·63	64·48	77·54
EXTRA-TROPICAL COAST AND ASSAM.	Chittagong	66·59	69·99	77·19	81·19	82·29	81·39	81·19	80·59	80·89	79·69	74·39	68·19	76·99
	Calcutta	65·15	69·15	78·85	85·15	85·25	84·75	83·05	82·45	82·45	79·85	72·05	65·15	77·85
	Kurrachee	65·29	67·72	75·29	79·88	84·65	86·66	84·25	82·20	81·79	79·99	74·00	67·42	77·43
	Cuttack	70·28	75·33	82·38	87·29	87·88	86·49	82·95	82·47	82·65	80·97	74·20	68·89	80·15
	Dhubri	62·56	64·86	74·46	79·06	78·86	80·06	82·16	81·26	79·76	78·16	71·06	64·56	74·76
	Sibsagar	58·44	61·64	65·24	73·94	78·14	82·64	83·74	83·24	81·54	77·34	68·24	60·64	73·14
EXTRA-TROPICAL INLAND.	Patna	61·01	65·51	77·51	86·51	88·51	87·91	84·61	84·01	83·91	79·61	70·21	62·91	77·71
	Hazaribagh	65·16	69·66	79·66	88·26	89·16	87·06	82·76	81·76	81·66	78·26	71·06	64·86	78·26
	Allahabad	60·80	65·15	77·66	88·20	92·45	91·96	85·43	83·96	83·76	78·76	68·83	61·06	78·17
	Jubbulpore	64·77	69·15	79·67	88·93	93·88	88·44	81·70	80·97	81·63	77·48	68·82	63·19	78·22
	Lucknow	59·35	64·13	75·89	86·77	90·60	91·64	86·14	84·44	83·78	77·40	66·79	59·42	77·17
	Agra	61·13	65·20	77·68	88·92	94·49	95·44	87·07	85·54	85·11	80·04	69·58	62·14	79·40
	Jaipur	62·76	66·43	77·61	85·24	93·82	93·11	86·43	84·29	84·61	80·41	70·75	64·18	79·39
	Roorkee	57·47	61·57	72·07	82·87	89·37	91·57	85·77	84·87	83·37	75·77	64·87	58·47	75·67
	Deesa	68·50	71·27	81·09	89·20	92·75	91·17	84·27	83·17	83·17	82·25	74·67	69·64	80·91
	Lahore	55·54	58·87	71·15	82·46	90·15	95·31	90·89	89·17	85·81	77·01	64·36	55·71	76·39
	Leh (Hills)	44·94	45·65	57·23	67·64	73·95	81·87	87·87	86·50	79·08	67·36	57·17	40·28	66·58

The data in Table XXV show that the mean monthly temperatures in India have at most of these stations only one minimum and maximum in the course of the year. At a few of the stations there is a feeble secondary minimum and maximum during the rainy season, the minimum usually in August and the corresponding maximum in September or October.

The primary minimum values of the monthly temperature means occur generally in January.

The exceptions are as follows:—

Station.	Minimum.		Station.	Minimum.	
	Amount.	Month.		Amount.	Month.
	°			°	
Trivandrum . . .	76·32	December.	Pachmarhi	56·64	December.
Bellary	72·49	Ditto	Cuttack	68·71	Ditto
Belgaum	69·01	Ditto	Hazaribagh	60·40	Ditto
Poona	68·42	Ditto	Jubbulpore	60·24	Ditto
Nagpur	66·77	Ditto			

The preceding data indicate that December is the month of minimum daily temperature at the interior stations in the Peninsula. At the coast stations, as in Northern India generally, January is the month of minimum temperature in the annual variation.

The maximum monthly temperatures occur in May at all stations with the following exceptions :—

Station.	Primary maximum.		Station.	Primary maximum.	
	Amount.	Month.		Amount.	Month.
	°			°	
Trivandrum . . .	80·98	April .	Dhubri	81·90	July.
Aden	87·96	June .	Sibsagar	83·00	July.
Rangoon	84·71	April .	Lucknow	90·82	June.
Trichinopoly . . .	85·11	April .	Agra	94·21	June.
Bellary	89·20	April .	Roorkee	89·60	June.
Belgaum	78·74	April .	Lahore	93·75	June.
Poona	84·26	April .	Simla	67·90	June.
Kurrachee	86·55	June .	Leh (Hills)	62·31	July.

The data of the table above indicate that there is a much greater variation in the epochs of the maximum monthly mean temperatures than in the minimum mean monthly temperatures in India. Thus in Lower Burma and at the interior stations of Southern India and in the Deccan April is the month of highest temperature. In Bengal, Bihar, Chota Nagpur, the Central Provinces, Central India and the greater part of Rajputana, the mean daily temperature is highest in May. In the greater part of Upper India including the Punjab, Sind, the western half of the North-Western Provinces and probably the north-western half of Rajputana, where the establishment of the monsoon rains is usually delayed until the beginning or middle of July, June is the month of highest mean day temperature. The Assam Valley is unique, as July (during the middle of the rains) is usually the month of greatest mean temperature. This is due to the peculiar local conditions prevailing in that area during the hot weather and the rains. Assam receives frequent, in fact almost daily, rain in April and May, chiefly from thunderstorms. Hailstorms are also

an occasional feature of the period. The rainfall accompanying these storms is heavy and gives monthly totals for these two months almost as large as in the height of the monsoon. On the other hand, during the South-West monsoon season proper, the humid currents from the Bay extend gradually over the interior westwards as far as the Punjab. The complete westerly extension of the monsoon rains to Upper India is usually effected in July. Hence in July and August the Bay current is determined mainly westwards up the Gangetic Plain. Assam is hence to some extent outside the influence of the main current and receives only moderate rain. This diminution of rainfall is further emphasized by the action of the cyclonic storms of the period which usually pass westwards across Northern or Central India and which hence tend to draw away rainfall from the outlying regions to the belt of country over which they pass.

The following mean monthly rainfall data for the following stations in the Assam Valley show the character of the rainfall in that area and illustrate the preceding remarks:—

Station.	Average Rainfall.						
	April.	May.	June.	July.	August.	September.	October.
	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.
Shillong	4·31	9·99	16·91	14·06	12·96	14·23	5·98
Sibsagar	9·92	11·40	14·20	15·90	16·18	11·79	5·00
Charduer	5·45	11·34	16·61	15·02	17·65	13·07	5·82
Gauhati	6·28	10·01	12·42	12·39	10·84	7·74	2·84
Dhubri	5·22	15·41	25·81	16·91	12·31	13·00	3·78

The dates of the coolest and hottest days in the year obtained from the mean daily temperature data are only known for a few stations at which hourly or continuous observations have been made for many years. The following gives data for these stations:—

Station.	Minimum daily temperature.		Maximum daily temperature.		Annual range of temperature determined from daily means.	Annual range of temperature determined from monthly means.
	Amount.	Date.	Amount.	Date.		
	°		°		°	°
Trivandrum	76·21	16th and 17th Dec.	81·01	2nd and 3rd April.	4·80	4·66
Bombay	73·30	1st to 7th Feb.	85·10	31st May and 1st June.	11·80	11·40
Madras	74·60	12th to 14th Jan.	87·50	26th and 27th May.	12·90	11·60
Calcuta	63·37	23rd and 26th Dec.	86·72	20th May.	23·25	20·10
Allahabad	58·40	8th and 9th Jan.	94·50	25th May.	36·10	31·65

The following gives approximate data for the remaining stations, as furnished by the daily normals used in the preparation of the India Daily Weather Reports:—

TABLE XXVII.

Giving the minimum and maximum mean daily temperatures and their dates of occurrence at twenty-four stations.

	Station.	Minimum daily mean temperature.		Maximum mean daily temperature.		Annual range of temperature determined from highest and lowest values of the daily mean temperature.	Annual range of temperature determined from monthly means.
		Amount.	Date.	Amount.	Date.		
		°		°		°	°
Tropical Coast.	Aden	76·5	16th and 19th January.	89·0	30th June	12·5	12·10
	Rangoon	75·3	7th, 10th and 11th January	87·7	22nd April	12·4	10·29
Tropical Inland.	Trichinopoly	76·0	23rd December	90·6	5th May	14·6	11·94
	Bellary	72·4	22nd and 25th December.	91·5	30th April and 1st May.	19·1	16·71
	Belgaum	69·0	31st December and 2nd Jan.	82·5	16th April	13·5	9·73
	Poona	67·9	22nd December	86·7	27th and 28th April.	18·8	15·84
	Nagpur	65·2	21st „	96·0	20th and 21st May.	30·8	27·20
	Pachmarhi (Hills)	55·7	20th December	85·4	29th May	29·7	28·14
Extra-Tropical Coast and Assam.	Chittagong	65·7	9th January	83·3	21st and 22nd May.	17·6	15·70
	Kurrachee	65·1	13th and 16th January.	88·4	9th June	23·3	21·37
	Cuttack	69·0	22nd and 23rd December.	91·8	30th April	22·8	18·99
	Dhubri	63·1	2nd and 9th January.	82·3	12th to 14th June.	19·2	19·60
	Sibsagar	59·0	4th and 5th January.	84·1	28th to 30th June.	25·1	25·30
Extra-Tropical Inland.	Patna	60·5	1st and 2nd January.	90·9	21st and 22nd May.	30·4	27·50
	Hazaribagh	59·3	21st and 22nd December.	88·4	20th and 21st May.	29·1	24·30
	Jubbulpore	58·6	21st December	93·4	29th May	34·8	30·69
	Lucknow	58·9	21st „	93·4	11th June	34·5	32·29
	Agra	59·9	31st „	97·5	3rd June	37·6	34·31
	Jaipur	59·3	1st February	93·6	29th May	34·3	31·06
	Roorkee	56·0	30th December	91·8	12th and 14th June.	35·8	34·10
	Deesa	65·7	28th January	93·8	27th May	28·1	22·67
	Lahore	53·5	30th and 31st December.	93·6	14th June	40·1	39·77
	Simla (Hills)	38·9	30th and 31st January.	69·1	12th „	30·2	27·40
	Leh (Hills)	19·6	21st January	64·6	3rd July	45·0	42·93

The data in the preceding table indicate that over nearly the whole of the interior of Northern India and the Peninsula, the coolest day of the year tends to occur in the last ten days of December. It is a few days earlier in the Deccan and Central Provinces than in Northern India and on the average of all stations in that area about the 21st December. In the Gangetic plain west of Patna it usually occurs between the 25th and 31st of December and on the average of all stations (omitting Lucknow) on the 30th December.

It is from a week to a fortnight later at the coast stations of Rangoon, Kurrachee, Chittagong and Madras. At Bombay it is delayed until the first week of February, due to the influence of cool waves from the north-west accompanying the cold weather storms of January and February.

It is also considerably delayed in the hills of Upper India where the coldest days are usually experienced in the last fortnight of January.

The hottest day of the year occurs in the last week of April in the South and West Deccan, in the last ten days of May in the Central Provinces, Chota Nagpur, Bengal, Bihar, Central India and Rajputana, in the first and second weeks of June in the North-Western Provinces, the East Punjab and Lower Assam Valley, in the last week of June in the Upper Assam Valley and in the first week of July at Leh. There is hence a fairly regular progression northwards of the epoch of the hottest day of the year, the range of the epoch extending over nearly eleven weeks, from the last week of April to the first week of July.

Amplitude of the annual variation or annual range of temperature.—The amplitude of the annual variation or range of temperature may be determined in various ways. It may be estimated by taking the difference of the maximum and minimum values of the mean monthly temperature. A second method employed is the difference between the lowest mean daily minimum and the highest mean daily maximum. A third method employed is to estimate it as the mean of the absolute range (the difference between the extreme temperatures recorded each year) for as many years as data are available. The second and third methods give measures differing slightly, whilst the first method furnishes measures much smaller than the second or third. The data are not of much importance for the present discussion.

In the following table (Table XXVIII) are given the maximum and minimum values of the monthly temperatures and their differences which represent the mean annual range of temperature as determined from the monthly means :—

TABLE XXVIII.—*Annual range of temperature at 29 stations determined from the monthly means of temperature.*

	Station.	Minimum	Month.	Maximum	Month.	Annual range.
		°		°		°
TROPICAL COAST.	Trivandrum	76·32	December	80·98	April	4·66
	Madras	75·10	January	86·70	May	11·60
	Bombay	73·80	"	85·20	"	11·40
	Aden	75·86	"	87·96	June	12·10
	Rangoon	74·42	"	84·71	April	10·29
TROPICAL INLAND.	Trichinopoly	76·17	"	88·11	"	11·94
	Bellary	72·49	December	89·20	"	16·71
	Belgaum	69·01	"	78·74	"	9·73
	Poona	68·42	"	84·26	"	15·84
	Nagpur	66·77	"	93·97	May	27·20
	Pachmarhi (Hills)	56·64	"	84·78	"	28·14

TABLE XXVIII—*concld.*

	Station.	Minimum.	Month.	Maximum.	Month.	Annual range.
		°		°		°
Extra-Tropical Coast and Assam.	Chittagong	66·40	January	82·10	May	15·70
	Calcutta	65·10	December and January.	85·20	"	20·10
	Kurrachee	65·18	January	86·55	June	21·37
	Cuttack	68·71	December	87·70	May	18·99
	Dhubri	62·30	January	81·90	July	19·60
	Sibsagar	57·70	"	83·00	"	25·30
Extra-Tropical Inland.	Patna	60·60	"	88·10	May	27·50
	Hazaribagh	60·40	December	84·70	"	24·30
	Allahabad	60·11	January	91·76	"	31·65
	Jubbulpore	60·24	December	90·93	"	30·69
	Lucknow	58·53	January	90·82	June	32·29
	Agra	59·90	"	94·21	"	34·31
	Jaipur	59·58	"	90·64	May	31·06
	Roorkee	55·50	"	89·60	June	34·10
	Deesa	67·46	"	91·71	May	24·25
	Lahore	53·98	"	93·75	June	39·77
	Simla (Hills)	40·60	"	67·90	"	27·30
	Leh (Hills)	19·38	"	62·31	July	42·93

The following are the chief facts regarding the annual variation of temperature as determined from the mean monthly values of the temperature:—

(1) The annual range is very small in the west coast districts of Southern India, including Travancore and Malabar, where it is less than 5° (as given by the data for Trivandrum).

(2) In the south and east of the Peninsula including the Coromandel coast districts, Mysore, Coorg and the West Deccan, and in Lower Burma it ranges between 10° (at Belgaum) and 17° (at Bellary).

(3) It ranges between 15° and 20° in Orissa, South Bengal and Lower Assam.

(4) It ranges between 20° and 30° in the Central and North Deccan and also in Chota Nagpur, Bihar, Upper Assam and West Rajputana (as represented by Deesa).

(5) It ranges between 30° and 40° in the North-Western Provinces, the Punjab, East Rajputana, Central India and the northern districts of the Central Provinces.

(6) It is absolutely greatest at Lahore in the plains of India (39°·8) and at Leh in the Upper Indus Valley (42°·9).

In the following table are given data of the annual ra. temperature data of the hourly observation memoirs and in pa year increases in amount mum and mean daily maximum data utilized in the prepara 27°) to Upper India (at Weather Report:—

largest and most eases in amount averages 4°. in Upper Central ar. ar.

TABLE XXIX.

STATION.	MEAN ANNUAL RANGE OF TEMPERATURE AS				
	Difference between non periodic maximum and minimum from the hourly temperatures of the year.	Difference between highest mean daily maximum and lowest mean daily minimum of the year.	Difference between highest mean monthly maximum and lowest mean monthly minimum temperatures of the year.	Difference between highest and lowest mean daily temperatures of the year.	high. lowest month. temperatu of the year.
	°	°	°	°	°
Lahore	63·9	68·7	65·0	40·1	39·8
Kurrachee	39·1	42·1	38·8	23·3	21·4
Roorkee	58·0	63·1	58·7	35·8	34·1
Agra	57·3	63·3	58·5	37·6	34·3
Jaipur	58·0	62·2	57·4	34·3	31·1
Lucknow	57·1	61·8	58·5	34·5	32·3
Deesa	54·4	57·3	54·8	28·1	22·7
Patna	51·7	53·9	51·0	30·4	27·5
Hazaribagh	46·3	52·8	48·1	29·1	24·3
Dhubri	34·0	38·4	34·5	19·2	19·6
Sibsagar	41·4	44·2	41·0	25·1	25·3
Cuttack	42·7	46·5	44·0	22·8	19·0
Chittagong	33·8	35·4	33·2	17·6	15·7
Rangoon	34·0	36·2	34·1	12·4	10·3
Jubbulpore	58·2	63·1	59·7	34·8	30·7
Pachmarhi	48·5	52·6	49·6	27·9	28·1
Nagpur	54·8	58·3	55·4	30·8	27·2
Poona	48·5	49·4	47·3	18·8	15·8
Belgaum	38·4	40·9	39·0	13·5	9·7
Bellary	42·9	45·7	43·4	19·1	16·7
Trichinopoly	33·2	36·6	34·2	14·6	11·9
Simla	?	?	30·0	30·2	27·4
Leh	67·2	72·8	67·8	45·0	42·9
Aden	21·4	23·0	21·8	12·5	12·1

The mean annual range in the preceding table is determined by five methods. The results differ slightly in the cases of the first, second and third methods (given in the corresponding columns), but vary largely from the results obtained by the fourth and fifth

methods. In the first figure column are given estimates of the mean annual range as determined by the differences between the non periodic maximum and minimum temperatures as deduced from the data of the hourly observation memoirs.

In the second figure column the mean annual ranges obtained are the differences between the mean lowest night temperature and highest day temperature as determined from the daily observations of upwards of 20 years and utilized in the preparation of the temperature variation data of the India Daily Weather Report.

In the third column of the table the annual ranges are measured by the differences between the highest mean monthly maximum and lowest mean monthly minimum and in the fourth figure column by the differences of the minimum and maximum values of the mean daily temperature. In the fifth column the annual range is determined from the highest and lowest mean monthly temperatures.

In the following table (Table XXX) are given the lowest mean minimum temperature and the highest mean maximum temperature as furnished by the mean diurnal data utilized in the preparation of the India Daily Weather Report (for the data of the columns headed variation from normal of the maximum and minimum temperatures). The differences of these figures are given in the third figure column and represent the mean absolute annual range of temperature at the twenty-eight stations under discussion.

In the fourth column are given data of the absolute range as determined from the actual absolute ranges of the nine years, 1891—99, and in the final column the differences between the estimates in the third and fourth columns.

TABLE XXX.

STATION.	Highest mean maximum temperature of the year.	Lowest mean minimum temperature of the year.	Mean absolute range. (a)	Absolute range as determined from the actuals of the period 1891-99. (b)	Difference (b)−(a)
	°	°	°	°	°
Lahore	107·4	38·7	68·7	82·3	13·6
Kurrachee	96·0	53·9	42·1	64·9	22·8
Roorkee	105·2	42·1	63·1	77·1	14·0
Agra	109·5	46·2	63·3	73·7	10·4
Jaipur	107·8	45·6	62·2	76·2	14·0
Lucknow	105·9	44·1	61·8	74·1	12·3
Allahabad	108·2	45·9	62·3	74·5	12·2
Deesa	107·5	50·2	57·3	74·5	17·2
Patna	102·7	48·8	53·9	66·3	12·4
Hazaribagh	101·0	48·2	52·8	65·1	12·3
Dhubri	91·0	52·6	38·4	52·0	13·6
Sibsagar	92·6	48·4	44·2	53·9	9·7
Calcutta	96·9	53·4	43·5	56·1	12·6
Cuttack	103·6	57·1	46·5	58·7	12·2
Chittagong	89·8	54·4	35·4	47·2	11·8

TABLE. XXX—*concluded.*

STATION.	Highest mean maximum temperature of the year.	Lowest mean minimum temperature of the year.	Mean absolute range. (a)	Absolute range as determined from the actuals of the period 1891-99. (b)	Difference (b)−(a).
	°	°	°	°	°
Rangoon	98·9	62·7	36·2	45·1	8·9
Bombay	90·9	66·5	24·4	32·9	8·5
Jubbulpore	105·7	42·6	63·1	73·8	10·7
Pachmarhi	95·4	42·8	52·6	65·1	12·5
Nagpur	109·5	51·2	58·3	67·6	9·3
Poona	102·0	52·6	49·4	61·3	11·9
Belgaum	97·1	56·2	40·9	50·2	9·3
Bellary	104·8	59·1	45·7	53·6	7·9
Trichinopoly	102·5	65·9	36·6	45·6	9·0
Madras	99·7	66·8	32·9	47·6	14·7
Trivandrum	88·1	70·5	17·6	25·6	8·0
Leh	80·4	7·6	72·8	92·5	19·7
Aden	94·6	71·6	23·0	32·3	9·3

It will be sufficient to discuss the values of the mean absolute range given in the fourth figure column.

(1) The absolute annual range is least in the Malabar coast districts where it is about 25°. It is slightly greater in the Konkan for which it is 33° as given by the Bombay data.

(2) It varies between 45° and 54° in the Coromandel coast districts and in the south and centre of the Deccan, and between 61° and 68° in the northern half of the Deccan (represented by Poona and Nagpur).

(3) It ranges between 45° and 59° in Assam and the Burma and Bengal coast districts and increases rapidly on preceding westwards up the Gangetic valley, where it averages 75°, to the Punjab. It is 82° at Lahore and 92°. 5 at Leh where it is greatest.

(4) The absolute range is hence three times as great in the more distant districts of the interior of Northern and Central India as it is in the Konkan and Malabar coast districts where it is least.

The law of the annual variation of temperature.—In the preceding paragraphs have been discussed the epochs of the maximum and minimum values of the temperature in its annual variation and also the range or amplitude of the variation. We have now to consider the law of that variation. The data (consisting of the monthly values of the mean temperature) for the 28 stations under discussion will be found in Table XXV, page 60.

The law of the annual variation of temperature differs very considerably in different parts of India. A comparison of the annual curves given in Plates X to XIII shows

the chief features, and is instructive, more especially as illustrating the varying effects of the wet monsoon in different parts of India. The following gives a few of the more interesting features:—

A.—The curve for Trivandrum (*vide* Fig. 15, Plate XI) probably represents the character of the annual variation at the Malabar and Ceylon coast stations and Port Blair. The annual variation is very small, not exceeding 5°. The mean monthly temperature is lowest in December and rises until April, when the occasional occurrence of thunder showers causes the mean temperature to decrease. It falls until June when the monsoon rains set in and is practically constant during the remainder of the year.

B.—The curves for Madras and Trichinopoly (*vide* Figs. 13 and 14, Plate XI) probably represent the annual variation in the Coromandel coast districts and South Central Madras. The mean monthly temperature is lowest in January, rises nearly uniformly to April or May, falls slowly due to the south-west monsoon influence until September and then more rapidly during the remainder of the year, due to the decreasing effect of solar radiation and the influence of the heavy rains which usually occur during that period.

C.—The curve for Bombay (*vide* Fig. 6, Plate XI) probably represents the annual variation for the Konkan coast. It differs slightly from the Madras curve, chiefly in that there is a slight rise in September and October at the end of the south-west monsoon. The curve has hence two maxima and minima; the absolute maximum and minimum being in May and January and the secondary minimum and maximum in August and October. The range of variation is about 11°.

The curve for Aden (Fig. 17, Plate XI) is similar in general form to that of Bombay. The absolute maximum is a month later (in June) and the secondary maximum a month earlier (in September).

The Rangoon curve (Fig. 5, Plate XI) is also similar to that of Bombay, the only important difference being that the hot weather maximum occurs a month earlier (in April) at Rangoon than at Bombay.

D.—The curves for Poona, Belgaum and Bellary (Figs. 10, 11 and 12, Plate XI) represent the annual variation in the West and South Deccan. That for Poona is probably most typical of this area. At these stations the mean monthly temperature increases rapidly from January to April, falls rapidly in June and July, increases slightly in September and October and falls rapidly in November and December. The representative curves have hence two maxima and minima, the primary values in April and December and the secondary in October and July.

E.—The annual variation at all stations in the interior of Northern and Central India and in the Central Provinces follows the same general law. At all these stations (including Nagpur, Pachmarhi, Cuttack, Patna, Allahabad, Lucknow, Agra, Jaipur, Deesa, Kurrachee and Lahore) the mean temperature rises rapidly from January to May or June. It falls rather rapidly in June and July, and is practically constant during the months of August and September and then falls rapidly during the remaining three months of the year.

The rise during the first five months of the year increases in amount northwards from the Central Provinces (averaging 27°) to Upper India (at Lahore) for which it averages 35°.

The fall in June and July due to the monsoon influence is largest and most marked in the Central Provinces (averaging 13°) and decreases in amount northwards to the Punjab as represented by Lahore for which it averages 4°. The fall from September to December is greatest and most rapid in Upper India (averaging 30°) and decreases in amount southwards to the Central Provinces where it ranges between 18° at Jubbulpore and 13° at Nagpur.

F.—The curves for Chittagong and Calcutta (Figs. 2 and 4, Plate XI) are similar. The curves for these stations differ from those of the stations named in E, in that the south-west monsoon influence is very slight. Temperature at these two stations increases rather rapidly from January to May and is practically constant (with a very slight tendency to decrease) during the next five months. It falls rapidly in November and December. The annual variation probably conforms to this type in Arakan, South Bengal and the Orissa coast districts.

G.—The Leh and Sibsagar curves (Figs. 1 and 16, Plate XI) are unique in that neither show the south-west monsoon influence to any extent.

The mean monthly temperature increases at each of these stations from January to July and decreases to December. The curves are fairly symmetrical. The range of variation is absolutely greatest at Leh of all the 28 stations under discussion, *viz.* 43°. It is considerably smaller in amount at Sibsagar for which it is 25°. The curve for Sibsagar probably represents the variation over the small area of the Upper Assam Valley, while that for Leh probably obtains over the whole of the high plateau of Thibet.

It may also be noted that the mean daily temperature at Leh is nearly constant for some time (from about the 30th January to the 8th February) at the minimum epoch and also for a longer period at the maximum epoch (*viz.*, from the 19th July to the 7th August). The rise of temperature is usually most rapid from the 8th to the 11th June, during which the mean daily temperature increases at the rate of nearly 1° per diem.

Diurnal variation of temperature.—This element of observation is not only important in itself as furnishing one of the chief indications of the climatic conditions, but is of the greatest importance for the present discussion as it is more or less directly related to the diurnal oscillation of pressure.

The general character of the variation is the same throughout, the representative curves having a single minimum (during the night hours) and a single maximum (during the day hours). The amplitude of the variation and the epochs of the maximum and minimum values vary considerably from season to season and the form of the curves also differ to some extent.

The subject is discussed under the following heads.

(1) Epochs of the maximum and minimum phases.
(2) Amplitude or range of variation.
(3) Law of variation with season and locality.
(4) Besselian formula.

(1) *Epochs of the maximum and minimum phases of the diurnal variation of temperature.—*

A.—*Epoch of the minimum phase of the diurnal variation of temperature.*—The following table (Table XXXI) gives data of the minimum epochs, on the mean or normal day of the year and also the earliest and latest monthly epochs during the year, at twenty-eight stations in India.

It should be noted that the epochs are calculated from the data of the harmonic or Besselian formula representing the diurnal variation of temperature.

TABLE XXXI.

Area.	Station.	Minimum epoch.					
		Mean day of the year.	Earliest.	Month.	Latest.	Month.	Range of epoch during year.
		A.M.	A.M.		A.M.		H. M.
Tropical Coast.	Trivandrum	4·51	4·34	May	5· 9	February	0 35
	Madras	5·28	5·18	May and June	6·16	January	0 58
	Bombay	5·34	5· 6	„ „	6·36	„	1 30
	Aden	5·26	4·39	May	6· 5	„	1 26
	Rangoon	5·27	4·37	July	6· 1	February	1 24
Tropical Inland.	Trichinopolly	5·20	5· 7	November	5·37	December	0 30
	Bellary	5·25	4·44	June	5·41	January	0 57
	Belgaum	5· 9	4·34	August	5·39	„	1 5
	Poona	5·23	4· 2	July	5·57	„	1 55
	Nagpur	5·20	4·38	May	5·50	„	1 12
	Pachmarhi (Hills)	5· 8	4·42	„	5·57	July	1 15
Extra-Tropical Coast and Assam.	Chittagong	5·32	4·43	„	6·10	January	1 27
	Calcutta	5·30	4·35	June	6·13	„	1 38
	Kurrachee	5·35	4·31	„	6·12	„	1 41
	Cuttack	5·32	4·38	„	6·14	„	1 36
	Dhubri	5·32	4·16	„	6·21	„	2 5
	Sibsagar	5·32	4·46	„	5·57	„	1 11
Extra-Tropical Inland.	Patna	5·30	5· 2	May	6· 0	„	0 58
	Hazaribagh	5·30	4·47	June	6·10	„	1 23
	Allahabad	5·31	4·59	May	6· 4	„	1 5
	Jubbulpore	5·27	4·47	July	6· 1	„	1 14
	Lucknow	5·18	4·55	May	5·46	„	0 51
	Agra	5·43	5· 6	June	6·22	„	1 16
	Jaipur	5·25	4·43	„	6· 0	„	1 17
	Roorkee	5·27	4·54	July	6·35	December	1 41
	Deesa	5·29	5· 3	September	5·51	„	0 48
	Lahore	5·31	4·50	July	6·17	January	1 27
	Leh (Hills)	5·13	4·34	May and June	5·52	„	1 18

Before discussing the data it is necessary to point out that there are considerable doubts as to the accuracy of the Lucknow observations. The Lucknow observer was originally one of the best observers in Northern India, but latterly became very careless and delegated his duties to subordinates and in some cases to peons, and it is probable that some of the peculiarities, or abnormal features in the Lucknow results are due to this fact and merely represent frequent careless and erroneous observation. It may also be noted that the shed at Agra was of a peculiar pattern which impeded the free circulation of the air. It was also shut in by buildings and walls at comparatively small distances. The temperature observations at that station are hence not strictly comparable with those at other stations and the results present abnormal features which are in part at least due to the abnormal conditions and exposure of the instruments and are hence not representative of local features or conditions of the meteorology of Agra and its neighbourhood The calculated epoch of the minimum at Trivandrum on the mean day of the year is 4-51 A.M., but the variations of temperature are so small during the night hours at that station that the methods of calculation adopted fail to give trustworthy results in such a case.

The data of the remaining 25 stations (which may be accepted as fairly accurate) indicate that the epoch of the minimum phase of the diurnal temperature oscillation on the mean of the year occurs at almost the same instant at all stations in the plains of India, and on the mean of the whole almost exactly at 5-28 A.M. or half-an-hour before the mean hour of sunrise. The data appear to indicate it is earliest at Nagpur (5-20 A.M.) and latest at Kurrachee (5-35 A.M.) The differences are however small, and in the great majority of cases within the limits of the errors of observation. The data for Pachmarhi and Leh indicate that the minimum occurs slightly earlier at the hill than the plain stations in India.

The results hence establish that over the whole of the plains of India, in the coast districts as well as in the interior, the epoch of the minimum of the diurnal variation of temperature of the mean day of the year is almost exactly half an hour before sunrise. It is, so far as can be inferred from the data of two stations, slightly earlier at the hill stations in Northern and Central India than at the neighbouring plains stations.

The epoch of the minimum phase of the diurnal variation of temperature varies throughout the year with the time of sunrise and is as a rule earliest in May and June and latest in January. There are a few local exceptions to this rule and it is not possible to determine from the observations whether this is due to observations not being numerous enough to eliminate irregularities or to the method of ascertaining the minimum epoch from the harmonic formula to four terms not being sufficiently accurate in this case, when the variations of temperature for sometime before the minimum epoch are very small as well as irregular. The range of variation of the minimum epoch varies so greatly from station to station as to suggest that the latter inference is probably correct.

The following gives the average difference between the epoch of the minimum and sunrise for the four groups of stations and for the four divisions of the year as

determined by the two methods of calculation, *viz.*, Jelinek's method and Lagrange's method:—

Season.	Difference between epoch of minimum and sunrise. (By Jelinek's method).			
	Extra-Tropical India.		Tropical India.	
	Inland.	Coast.	Inland.	Coast.
	H. M.	H. M.	H. M.	H. M.
Cold season	0 43	0 42	0 57	0 40
Hot season	0 28	0 31	0 44	0 50
Rainy season or south-west monsoon	0 24	0 39	0 39	0 32
Retreating south-west monsoon	0 45	0 36	0 52	0 35

Season.	Difference between epoch of minimum and sunrise (By Lagrange's method).			
	Extra-Tropical India.		Tropical India.	
	Inland.	Coast.	Inland.	Coast.
	H. M.	H. M.	H. M.	H. M.
Cold season	0 30	0 26	0 39	0 24
Hot season	0 14	0 15	0 21	0 49
Rainy season south-west monsoon	0 13	0 24	0 24	0 32
Retreating south-west monsoon	0 36	0 21	0 30	0 23

The preceding data suggest that there is a tendency for the minimum to occur a few minutes later (in the morning) in the coast districts than in the interior of India during the retreating south-west monsoon period and cold season, and for it to occur slightly earlier in the coast districts than in the interior during the hot and rainy seasons.

The following table gives data for the four groups of stations for the mean day of the year and the mean range of variation:—

Group.	Epoch of minimum on the mean day of the year.	Mean difference between the earliest and latest monthly epoch.
	A. M.	H. M.
Extra-Tropical Inland (excluding Lucknow and Agra)	5·27	1 15
Extra-Tropical Coast and Assam	5·32	1 36
Tropical Inland	5·18	1 9
Tropical Coast (excluding Trivandrum)	5·29	1 20

The results are interesting as showing the contrast between the variability at the inland and the coast stations.

B.—*Epoch of the maximum phase of the diurnal variation of temperature.*—The following table (Table XXXII) gives data of the epochs of maximum temperature at 28 stations:—

TABLE XXXII.

Area.	Station.	Maximum epoch.					Range of epoch during year
		Mean day of the year.	Earliest.	Month.	Latest.	Month.	
		P.M.	P.M.		P.M.		H. M.
Tropical Coast.	Trivandrum	1-34	0-21	October	2-23	January	2 2
	Madras	1-32	0-46	April	2- 7	August	1 21
	Bombay	2-29	1-16	July	2-36	October and December to February.	1 20
	Aden	2-30	11-24 A.M.	October	5-30	July	6 6
	Rangoon	1-50	11-59 A.M.	August	2-32	January	2 33
Tropical Inland.	Trichinopoly	2-39	P.M. 1-30	December	3-17	February	1 47
	Bellary	2-49	2- 5	July	3-20	"	1 15
	Belgaum	2- 1?	0-45?	"	3-3?	January	2 18?
	Poona	2-24	0-48	August	3-20	February	2 32
	Nagpur	2-50	1-11	July	3-23	January	2 12
	Pachmarhi (Hills)	2-52	2-23	September	3- 7	April	0 44
Extra-Tropical Coast and Assam.	Chittagong	1-49	0- 4	June	1-56	October	1 52
	Calcutta	2-44	1-10	August	3-28	February	2 18
	Kurrachee	1-25	0-54	April	2- 7	"	1 13
	Cuttack	2-17	0-17	August	2-54	"	2 37
	Dhubri	2-44	1-25	"	3-10	April	1 45
	Sibsagar	2-56	2-30	November	3-29	July	0 59
Extra-Tropical Inland.	Patna	2-47	2-23	September	3- 9	August	0 46
	Hazaribagh	2-10	1-11	"	2-30	January to April and October to December.	1 19
	Allahabad	2-23	1-56	November	2-56	June	1 0
	Jubbulpore	2-47	2-17	August	3-14	March	0 57
	Lucknow	2-45?	2-22?	December	3- 8?	"	0 46?
	Agra	3- 3?	2-33?	August	3-25?	"	0 52?
	Jaipur	2-50	2-30	"	3-14	"	0 44
	Roorkee	2-34	1-51	June	3-54	July	2 3
	Deesa	2-56	2-38	November	3-16	March	0 38
	Lahore	2-36	2-18	"	3- 3	June	0 45
	Leh (Hills)	2-22	1-58	January	2-47	"	0 49

The mean epochs of the maximum vary within much wider limits than those of the

minimum. The following appear to be the more important inferences from the preceding data :—

(1) The epoch of the maximum phase at the inland stations in Northern or Extra-Tropical India, excluding Lucknow and Agra, is on the mean of the year 2-36 P.M. It is, on the whole, slightly later at the stations most remote from the coast than at the coast stations.

(2) The epoch of the maximum phase at the coast stations in Northern or Extra-Tropical India is on the mean of the year 2-19 P.M., and hence 17 minutes earlier than at the inland stations in Northern India.

(3) The epoch of the maximum phase at the inland stations in the Peninsula (excluding Belgaum where the conditions appear to differ considerably from other stations) is 2-43 P.M., and hence practically at the same instant as the corresponding epoch in Northern India.

(4) The epoch of the maximum phase on the mean of the year at the coast stations in the Peninsula and Burma is 1-51 P.M., and hence almost simultaneous with the corresponding epoch at the more northerly coast stations in India and 52 minutes earlier than at the interior stations of the Peninsula.

(5) The epoch of the maximum is, as a rule, earliest in the rains (*i.e.*, June to September). This is the case at 16 out of 26 stations. The early occurrence of the epoch at Allahabad, Deesa and Lahore in November is probably not a real climatic feature, but due to the observations not being sufficiently numerous to eliminate irregularities. Lucknow, it will be seen, again presents abnormal features, almost certainly not real, but due to imperfect or erroneous observations.

(6) The epoch of the maximum over the whole of India is, as a rule, latest in the dry season months and chiefly in January, February and March. Out of the 26 Indian stations it is earliest in the day at five stations in January, at six stations in February and at five stations in March. It is later at the hill stations than in the plains and is very abnormal in its occurrence at Aden (ranging between 11-24 A.M. and 5-30 P.M.)

(7) The range of variation of the epoch of the maximum during the year is greatest at the coast stations (at which it averages about 2 hours) and is least in the interior of Northern India, where it varies very slightly and averages 45 minutes approximately.

The following gives data for the four groups of stations and for the mean day of the year and the mean variation :—

Group.	Epoch of maximum on the mean day of the year.	Mean difference between the earliest and latest monthly epoch.	
	P.M.	H.	M
Extra-Tropical Inland (excluding Lucknow and Agra) .	2-36	1	0
Extra-Tropical Coast and Assam	2-19	1	47
Tropical Inland (excluding Belgaum)	2-43	1	42
Tropical Coast (excluding Aden)	1-51	1	49

The differences in the epoch of the maximum between the coast and the inland stations appear to be mainly an effect of the distribution of cloud. The diurnal variation of the amount of cloud varies very considerably in different seasons and in different parts of India. In the dry weather there is always a considerable increase in the afternoon hours. This increase is most marked in the coast districts and in the submontane districts of Northern India, and is in part due to the large convective movements in the interior and in part to variations in the strength of the local sea winds or to the inter-action of land and sea winds. This cloud formation usually commences earlier, and is more pronounced in the neighbourhood of the coasts in India than in the interior, and is latest and least marked in the dry districts of Upper India.

Similar considerations explain the unusually early epoch of the maximum at Belgaum and Trivandrum during the period of severe thunderstorms in the hot weather, and at stations such as Nagpur near hills where there is a large and pronounced afternoon increase in the amount of cloud.

(2) *Amount or amplitude of the diurnal variation of temperature*—The two following tables give a summary of the data utilized in the discussion of this feature. Table XXXIII gives the mean diurnal range of temperature for each month of the year and for the mean day of the year and Table XXXIV a summary of the data in Table XXXIII arranged according to seasons and also the maximum and minimum values and the months of their occurrence.

TABLE XXXIII.—*Mean diurnal range of temperature for each month of the year and for the whole year.*

AREA.	STATION.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Year.
		°	°	°	°	°	°	°	°	°	°	°	°	°
TROPICAL COAST	Trivandrum	15·24	15·38	14·20	12·38	10·37	9·47	9·00	9·57	9·85	10·38	11·79	13·49	11·76
	Madras	17·10	18 60	17·10	15·70	17·00	18·00	17·10	16·40	16·10	13·80	12 70	13·80	16·10
	Bombay	14·40	14·10	12·10	10·90	9·60	8·00	6·60	7·20	8·00	11·10	13·40	14·60	10·80
	Aden	9·25	9·32	10·48	12·91	12·79	10·73	10·98	11·28	11·45	13·75	12·69	9·89	11·28
	Rangoon	24·66	26·96	25·63	22·17	15·44	9·91	9·53	9·37	9·61	10·98	14·54	20·12	16·34
TROPICAL INLAND.	Trichinopoly	20·56	24·09	24·76	23·68	22·80	20·52	19·62	19·71	19·86	16·89	15·24	15·89	20·32
	Bellary	27·14	29·14	28·08	26·75	24·95	18·98	16·54	17·28	17·79	18·71	21·19	24·74	22·62
	Belgaum	26·02	28·98	29·44	28·21	25·06	12·32	8·49	9·81	13·35	17·40	20·59	23·18	20·26
	Poona	32·54	35·19	34 04	32·88	28·51	16·89	11·59	12·57	15·59	22·00	26·68	30·74	24·89
	Nagpur	27·45	29·41	30·37	29·75	27·48	20·22	12·66	12·85	15·19	21·07	24·66	26·77	23·09
	Pachmarhi (Hills)	23·55	24·15	23·78	22·71	19·78	14·19	7·52	7·68	10·91	18·29	22·57	25·09	18·35
EXTRA-TROPICAL COAST AND ASSAM.	Chittagong	22·60	22 90	18·70	15·90	13·20	9·70	9·10	9·90	10·50	13·30	16·80	20·70	15·30
	Calcutta	21·40	22·00	20·60	19·70	16·40	12·40	9·40	9·10	9·60	12·40	16·80	20·30	15·80
	Kurrachee	21·92	21·20	19·33	16·91	14·39	11·46	9·39	9·19	11·40	19·97	25·22	23·60	17·00
	Cuttack	24 73	24·80	24·18	24·00	21 50	15·73	11·38	12·40	12·05	15·18	19·52	23·87	19·01
	Dhubri	19·81	21·10	21·38	16·16	13·59	13 20	8·28	11·21	8·19	11·49	16·13	18·48	14·33
	Sibsagar	19·80	19·90	19·00	16·00	14·60	9·47	12·70	7·94	12·70	14·50	18·80	21·34	16·20

TABLE XXXIII.—*Mean diurnal range of temperature for each month of the year and for the whole year*—concld.

Area.	Station.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Year.
		°	°	°	°	°	°	°	°	°	°	°	°	°
Extra-Tropical Inland.	Patna	22.80	25.40	27.50	27.60	22.40	16.50	10.60	9.80	11.10	15.80	21.50	23.00	19.50
	Hazaribagh	21.60	22.60	23.90	24.80	23.30	15.60	10.20	10.20	11.60	15.50	18.80	21.00	18.40
	Allahabad	26.65	28.65	30.83	30.90	27.16	19.24	12.33	11.23	14.42	22.50	28.35	27.89	23.35
	Jubbulpore	28.99	29.82	31.68	30.92	26.46	18.56	10.97	10.75	14.09	22.49	28.80	30.57	23.66
	Lucknow	27.52	28.12	30.59	31.10	27.55	20.19	13.34	12.42	15.61	25.03	30.83	29.59	24.32
	Agra	24.65	26.14	28.11	28.96	25.76	20.03	12.79	12.12	15.59	24.50	28.63	27.27	22.88
	Jaipur	25.06	27.53	29.01	31.10	29.09	22.15	15.01	14.95	20.29	29.18	31.37	29.11	25.33
	Roorkee	26.68	25.47	28.81	30.23	26.89	22.31	13.80	14.41	18.64	28.32	31.11	27.92	24.55
	Deesa	31.33	31.35	32.00	32.43	29.00	21.24	13.99	13.14	18.84	29.64	33.66	33.16	26.62
	Lahore	24.86	24.50	26.45	28.21	28.42	25.32	18.12	17.89	21.22	29.79	31.36	28.12	25.50
	Simla (Hills)	5.40	11.00	12.40	14.30	14.20	14.70	8.70	7.70	10.60	11.70	11.70	6.60	10.80
	Leh (Hills)	21.04	22.29	23.01	25.17	26.52	27.40	27.52	27.68	28.14	27.95	26.09	21.90	25.44

TABLE XXXIV.—*Mean diurnal range of temperature for each season of the year and for the whole year.*

Area.	Station.	Year.	January and February.	March to May.	June and September.	July and August.	June to August.	October to December.	Greatest monthly.		Least monthly.	
									Amount	Month.	Amount.	Month.
		°	°	°	°	°	°	°	°		°	
Tropical Coast.	Trivandrum	11.76	15.31	12.32	9.66	9.29	9.35	11.89	15.38	February	9.00	July.
	Madras	16.10	17.90	16.60	17.10	16.80	17.20	13.40	18.60	"	12.70	November.
	Bombay	10.80	14.30	10.90	8.00	6.90	7.30	13.00	14.60	December	6.60	July.
	Aden	11.28	9.29	12.06	11.09	11.13	11.00	12.11	13.75	October	9.25	January.
	Rangoon	16.34	25.01	21.08	9.76	9.45	9.60	15.21	26.96	February	9.37	August.
Tropical Inland.	Trichinopoly	20.32	22.33	23.75	20.19	19.67	19.95	16.01	24.76	March	15.24	November.
	Bellary	22.62	28.14	26.59	18.39	16.91	17.60	21.55	29.14	February	16.54	July.
	Belgaum	20.26	27.50	27.57	12.84	9.15	10.21	20.39	29.44	March	8.49	"
	Poona	24.89	33.87	31.81	16.24	12.08	13.68	26.47	35.19	February	11.53	"
	Nagpur	23.09	28.43	29.20	17.71	12.76	15.24	24.17	30.37	March	12.66	"
	Pachmarhi (Hills)	18.35	23.85	22.09	12.55	7.60	9.80	21.98	25.09	December	7.52	"
Extra-Tropical Coast and Assam.	Chittagong	15.30	22.80	15.90	10.10	9.50	9.60	16.90	22.90	February	9.10	"
	Calcutta	15.80	21.70	18.90	11.00	9.30	10.30	16.50	22.00	"	9.10	August.
	Kurrachee	17.00	21.56	16.88	11.43	9.29	10.01	22.93	25.22	November	9.19	"
	Cuttack	19.01	24.77	23.23	13.89	11.30	12.77	19.52	24.80	February	11.21	"
	Dhubri	14.33	20.46	17.04	8.83	8.11	8.56	15.33	21.38	March	7.94	"
	Sibsagar	16.20	19.90	16.50	13.00	12.60	12.80	18.30	21.50	December	12.40	"

TABLE XXXIV.—*Mean diurnal range of temperature for each season of the year and for the whole year*—concld.

Area.	Station.	Year.	January and February.	March to May.	June and September.	July and August.	June to August.	October to December.	Greatest monthly. Amount.	Greatest monthly. Month.	Least monthly. Amount.	Least monthly. Month.
		°	°	°	°	°	°	°	°		°	
Extra-Tropical Inland.	Patna . . .	19·50	24·10	25·80	13·80	10·20	12·30	20·10	27·60	April .	9·80	August.
	Hazaribagh . .	18·40	22·10	24·00	13·60	10·20	12·00	18·40	24·80	" . .	10·20	July and August.
	Allahabad . .	23·35	27·65	29·63	16·83	11·78	14·27	26·25	30·90	" . .	11·23	August.
	Jubbulpore . .	23·66	29·41	29·69	16·33	10·86	13·43	27·29	31·68	March .	10·75	"
	Lucknow . . .	24·32	27·82	30·08	17·90	12·88	15·32	28·48	31·10	April .	12·42	"
	Agra . . .	22·88	25·40	27·61	17·81	12·46	14·98	26·80	28·96	" . .	12·12	"
	Jaipur . . .	25·33	26·30	29·73	21·22	14·98	17·37	29·89	31·37	November .	14·95	"
	Roorkee . .	24·55	26·08	28·64	20·48	14·11	16·84	29·12	31·11	" .	13·80	July.
	Deesa . . .	26·62	31·34	31·14	20·04	13·57	16·12	32·15	33·66	" .	13·14	August.
	Lahore . . .	25·50	24·68	27·69	23·27	18·01	20·44	29·76	31·36	" .	17·89	"
	Simla (Hills) . .	10·80	8·20	13·60	12·70	8·20	10·40	10·00	14·70	June .	5·40	January.
	Leh (Hills) . .	25·44	21·67	24·90	27·77	27·60	27·53	23·31	28·14	September.	21·04	"

The following are the more important facts of the diurnal range of temperature over India as indicated by the data of Tables XXXIII and XXXIV.

(1) The mean diurnal range is large in the cold weather months of January and February. It is smallest in average amount in the cold weather season at the coast stations of Trivandrum, Bombay and Madras, at which it ranges between 14°·3 and 17°·9. It is very large in this season at Rangoon, as large as in the interior of India, due to the frequent prevalence of dry northerly land winds. It is moderately large in the coast districts of Extra-Tropical India and in Assam, ranging between 19°·9 at Sibsagar and 24°·8 at Cuttack, and averaging 21°·9. It is large over the whole of the interior where dry land winds prevail more or less steadily. It is, generally slightly larger in amount in the Deccan and Central Provinces than in Northern India. The Deccan is, on the whole, the driest area in India during the period, and is also remarkably free from disturbance and cloud. These are probably the conditions which give the very large range in the West Deccan, where it is actually highest at Poona, averaging 33°·9 for the period and 35°·2 for the month of February, the highest monthly average for any station. The mean diurnal variation in the plains of Northern and Central India, *i.e.*, Extra-Tropical Inland ranges, between 22°·1 at Hazaribagh and 31°·3 at Deesa and averages 26°·5.

(2) The mean diurnal range is also large over nearly the whole of India in the hot season. It is slightly less in amount in the coast districts due to the increasing influence of the sea winds throughout the period, but is generally larger in Northern and Central India than in the cold weather. The mean range in the Tropical coast districts (omitting Rangoon) is 13°, in the Extra-Tropical coast districts and Assam (including Rangoon) 18°·5, at the Tropical interior stations 27°·8, and at the Extra-Tropical inland stations (where it is greatest) 28°·4.

(3) The mean diurnal range is small in the humid months of the rainy season. It is absolutely greatest at this season in the driest districts including the Punjab, North-West Rajputana, Upper Sind, and the interior of Southern India. The range in July and August averages 11° in the Tropical Coast districts (ranging between 6°·9 at Bombay and 16°·8 at Madras) and 12°·9 in Extra-Tropical India (ranging between 10°·2 at Patna and Hazaribagh and 18° at Lahore). It ranges between 9°·2 at Belgaum and 19°·7 at Trichinopoly, and averages 14°·1 for the interior of the Peninsula or Tropical India. The diurnal range during the height of the season ranges from 7° to 9°·5 in the coast districts fully exposed to the influence of the south-west monsoon humid currents and 10° to 18° in the interior districts of Northern and Central India and the North Deccan.

(4) The mean diurnal range in the retreating south-west monsoon period from October to December is similar in amount to that of the cold weather. In Extra-Tropical India the values for the plains stations average 26°·8, slightly greater than for the cold weather, due to the fine weather and small cloud amount in the period, October to December. It is actually greatest at Deesa where it averages 32°·2 for the period. The diurnal range is less at the coast stations in Extra-Tropical India in this period than in the cold weather, due to greater humidity and more frequent cloud. It averages 18°·2 at these stations. It is also considerably less in the Peninsula, due to the same actions and conditions, averaging 13° for the coast stations and 21°·7 for the inland stations.

(5) The diurnal range is greatest in North-Western India in November when the air movement is very feeble, the air very dry and skies most free from cloud or dust. The mean diurnal variation exceeds 30° in this month at the following stations at which hourly observations were recorded :—

	°
Jaipur	31·37
Deesa	33·66
Lahore	31·36
Roorkee	31·11

It is hence greatest at Deesa which is under the full influence of the dry land winds from Rajputana. Kurrachee follows the same rule, its maximum range being 25°·2 in November.

It is, it may be added, absolutely greatest at the following stations in India not included in the list of the stations which recorded hourly observations :—

	°
Jacobabad	36·5
Sirsa	36·3
D. I. Khan	35·7

(6) The diurnal range is greatest in February and March at the majority of stations on the coast and in the interior of the Peninsula The amount of the range depends upon the extent to which land or sea winds prevail and is greatest in those districts in the interior which come under the maximum

influence of the alternating land and sea breezes. The following gives the most noteworthy maximum values for this group of stations: —

Station.	Amount.	Month.
	°	
Poona	35·19	February.
Jubbulpore	31·68	March.
Nagpur	30·37	„
Belgaum	29·44	„
Rangoon	26·96	February.
Cuttack	24·80	„

(7) The diurnal range is a maximum in April in the Gangetic Plain east of Agra. It exceeds 30° at the stations for which data are given below:—

Lucknow	31°·1
Allahabad	30°·9

(8) The data show that the maximum diurnal range does not differ to any large extent over by far the greater part of the interior, ranging between 28° and 34° over nearly the whole of Bihar, the North-Western Provinces, the Punjab, Rajputana, Central India, the Central Provinces and the Deccan. The absolute maximum, as already noted, is 35°·2 at Poona in February.

(9) The diurnal range is smallest in July and August at the great majority of stations, in July at stations in the interior of the Peninsula and West Coast districts, and in August over practically the whole of Central and Northern India and in November in Southern India represented by Madras and Trichinopoly. The smallest ranges (less than 9°) are as follow:—

Station.	Lowest monthly mean diurnal range of temperature.	Month.
	°	
Bombay	6·60	July.
Pachmarhi	7·52	July.
Dhubri	7·94	August.
Belgaum	8·49	July.

The absolute minimum mean monthly range of diurnal variation is at Simla 5°·4 in January.

(3) *Law of the diurnal variation of temperature.*—There are several well-marked types, and it will probably be sufficient to confine ourselves to the consideration of these. The following gives the more important types, *viz.* :—

1st.—That of the inland stations in Northern India during the dry weather months (from October to May).

2nd.—That of the inland stations in Northern India during the humid months of July and August, representing fully the south-west monsoon conditions and influence.

3rd.—That of the inland stations in the plateau of the Peninsula and Central India during the dry weather months (from December to May).

4th.—That of the stations in the interior or the Peninsula during the rains.

5th.—That of the coast stations in India in the dry weather or during the prevalence of land winds.

6th—That of the coast stations during the prevalence of sea winds.

(1) The first type is that of the interior stations in Northern India during the dry weather months from October to May.

The following give the chief features of this type of the diurnal variation of temperature in India :—

(*a*) The minimum temperature of the day occurs about half an hour before sunrise.

(*b*) Temperature increases rapidly from 6 or 7 A.M. up to noon.

(*c*) Temperature increases slightly from noon to about 2-30 P.M. when as a rule it is highest.

(*d*) Temperature decreases slightly from 2-30 P.M. to 4 P.M.

(*e*) Temperature decreases rapidly from 4 P.M. to 8 P.M.

(*f*) Temperature decreases slowly during the remainder of the night from 8 P.M. to 5-30 A.M.

The following data of Lahore for the month of April illustrate these features:—

PERIOD.	Total change in temperature during period in April.	Mean hourly rate of change during period in April
	°	°
6 A.M. to noon	+22·07	+3·68
Noon to 3 P.M.	+ 2·32	+0·77
3 P.M. to 4 P.M.	— 0·80	—0·80
4 P.M. to 10 P.M.	—16·71	—2·78
10 P.M. to 6 A.M.	— 6·88	—0·86

The following gives mean data corresponding to the first column of the previous table for the inland Extra-Tropical stations for each month of the period October to May.—

PERIOD	October.	November	December	January	February.	March.	April	May
	°	°	°	°	°	°	°	°
6 A.M. to noon	+20·23	+23·89	+22·81	+21·09	+21·81	+22·61	+22·51	+19·37
Noon to 3 P.M.	+ 2·14	+ 2·22	+ 2·37	+ 3·05	+ 2·96	+ 3·12	+ 2·92	+ 2·78
3 P.M. to 4 P.M.	— 1·64	— 1·99	— 1·82	— 1·26	— 0·89	— 0·79	— 0·78	— 0·81
4 P.M. to 10 P.M.	—14·59	—16·20	—15·52	—15·00	—15·57	—16·43	—16·74	—14·62
10 P.M. to 6 A.M.	— 6·14	— 7·50	— 7·83	— 7·88	— 8·31	— 8·54	— 7·99	— 6·61

The curves (Figs. 1, 2, 19 and 20, Plate XV) showing the mean diurnal variation of temperature of Lahore and Allahabad in the interior of Northern India in the dry and hot seasons are good examples of the type. Curves were prepared showing the change of

temperature during each hour of the day, but it was not thought necessary to give them except for the mean day of the year (Figs. 21 to 24, Plate XIV). These curves, it may be noted, differ very largely from the curves showing the mean variation of the intensity of solar radiation at the earth's surface during the day, as measured directly by means of observation of solar radiation thermometers, and also from the curves showing the rate of change of the solar radiation temperature. (*Vide* curves, Plates VI and VII).

(2) The second type is that of the interior stations of Northern India during the full prevalence of the south-west monsoon conditions, *i.e.*, the months of July and August.

(*a*) Temperature is lowest at about 5-30 A.M. or very shortly before sunrise.

(*b*) It increases slowly until about 2 P.M. and is practically unchanged until 4 P.M.

(*c*) It falls moderately from 4 P.M. to 8 P.M. and then very slightly during the remainder of the night from 8 P.M. to 5·30 A.M.

The curves for Jubbulpore and Allahabad in July and August (Fig. 19, Plate XIX, and Fig. 13, Plate XXI,) are good examples of this type of variation.

The following table giving the changes of temperature at Allahabad during four-hourly periods of the day illustrates these features clearly:—

Period.	Change of temperature at Allahabad.	
	Mean of July and August.	Hourly rate of change.
	°	°
Midnight to 4 A.M. ...	−1·44	−0·36
4 A.M. to 8 A.M.	+2·52	+0·63
8 A.M. to noon ...	+5·34	+1·34
Noon to 4 P.M. ...	+0·24	+0·36
4 P.M. to 8 P.M. ...	−5·07	−1·27
8 P.M. to midnight ...	−1·59	−0·40

(3) The third type of diurnal variation of temperature is that of inland stations in Tropical India during the dry weather period from December to May. The variation at these stations in October and November, when frequent rain due to the retreating south-west monsoon occurs, belongs rather to the next than the present type.

The chief features are:—

(*a*) The minimum temperature is recorded about 5-30 A.M. or shortly before sunrise.

(*b*) Temperature begins to increase at 6 A.M. and increases rapidly from 6 A.M. to 11 A.M. and thence moderately to slightly until the epoch of the maximum of the day at about 2-45 P.M.

(*c*) Temperature falls rapidly from 3 P.M. to 8 P.M. and thence moderately during the remainder of the night.

The curves of Bellary for the months of January to May (Plate XLIII, Vol. IX, Indian Meteorological Memoirs) are excellent examples of this type of curve.

The following table giving four-hourly changes of temperature at Bellary in each of these months illustrates the chief features of this type :—

PERIOD.	CHANGE OF TEMPERATURE AT BELLARY.				
	January.	February	March.	April.	May.
Midnight to 4 A.M.	$-3^\circ.89$	$-4^\circ.39$	$-3^\circ.97$	$-4^\circ.48$	$-4^\circ.72$
4 A.M. to 8 A.M.	$+3.73$	$+4.09$	$+4.51$	$+4.53$	$+4.72$
8 A.M. to noon	$+15.18$	$+15.84$	$+14.92$	$+12.87$	$+11.68$
Noon to 4 P.M.	$+3.41$	$+3.78$	$+2.87$	$+3.32$	$+2.06$
4 P.M. to 8 P.M.	-11.71	-12.05	-11.19	-10.07	-8.40
8 P.M. to midnight	-6.72	-7.27	-7.14	-6.17	-6.24

(4) The fourth type of diurnal variation of temperature is that of stations in the interior of the Peninsula during the full influence of the south-west monsoon conditions. The diurnal variation conforms most closely to this type at stations in the northern districts, (*i.e.*, in the Deccan, Berar and the southern half of the Central Provinces) in the months of June to September and in Southern India from September to November or December. The chief features are :—

(*a*) Temperature in its diurnal variation is lowest at about 5-15 A.M.

(*b*) Temperature increases moderately from 6 A.M. to noon and slightly from noon to about 2-15 P.M. when the maximum of the day occurs.

(*c*) Temperature falls slightly from 2-30 P.M. to 4 P.M., moderately from 4 P.M. to 8 P.M., and slightly between 8 P.M. and 5 A.M.

(*d*) The range of variation is greater at the southern than the northern stations in the interior of the Peninsula.

The curves of Poona for the months of July and August (Plate XXX, Vol. IX, Indian Meteorological Memoirs) and of Trichinopoly for October, November and December (Plate XLIX, Vol. IX, Indian Meteorological Memoirs) are good examples of this type of variation.

The following gives four-hourly mean changes of temperature during the day at these two stations in the months named :—

PERIOD.	CHANGE OF TEMPERATURE AT				
	POONA		TRICHINOPOLY.		
	July.	August	October.	November.	December.
Midnight to 4 A.M.	$-0^\circ.86$	$-0^\circ.78$	$-1^\circ.84$	$-1^\circ.80$	$-1^\circ.58$
4 A.M. to 8 A.M.	$+2.97$	$+3.48$	$+2.99$	$+3.89$	$+2.32$
8 A.M. to noon	$+4.81$	$+5.70$	$+7.37$	$+6.51$	$+7.18$
Noon to 4 P.M.	-1.95	-1.74	-0.28	-0.73	-0.83
4 P.M. to 8 P.M.	-4.08	-5.46	-5.83	-5.31	-4.88
8 P.M. to midnight	-0.89	-1.26	-2.41	-2.56	-2.21

(5) The fifth type is that which obtains at coast stations when dry land winds prevail steadily or when land and sea breezes alternate. The curves of Kurrachee from October

to February are good examples of the former, and of Bombay in the months of January, of February and March, of the latter.

The chief difference in the two classes of this type is not of form but of amplitude or range of variation.

The chief features of this type are as follows :—

(*a*) The epoch of the minimum is at 6 A. M.

(*b*) Temperature rises rapidly until 11 A.M. and thence moderately to slightly until 1 P.M. Temperature falls slightly until 2 P.M. and thence rapidly until 8 P. M. and very slightly during the remainder of the night.

The following gives four-hourly changes of temperature during the day in the months selected at these two stations : —

Period.	Kurrachee.					Bombay.		
	October.	November.	December.	January.	February.	January.	February.	March.
	°	°	°	°	°	°	°	°
Midnight to 4 A.M.	−2·93	−3·41	−3·10	−3·27	−2·75	−1·7	−1·7	−1·5
4 A.M. to 8 A.M.	4·09	+4·38	+2·42	+1·25	+1·27	+1·3	+1·8	+2·4
8 A.M. to noon	+13·14	+16·89	+17·08	+15·38	+14·34	+8.3	+8·1	+6·2
Noon to 4 P.M.	−3·55	−2·21	−1·05	+0·06	−0·07	+1·2	+1·0	+0·4
4 P.M. to 8 P.M.	−7·87	−9·88	−9·66	−8·57	−8·47	−6·0	−6·2	−5·3
8 P.M. to midnight	−2·88	−5·77	−5·69	−4·85	−4·32	−3·1	−3·0	−2·2

(6) The sixth type is that of the coast stations under the full influence of the south-west monsoon conditions and winds. The curves of Bombay for the months of July and August (Fig. 10, Plate XXI) are on the whole the best examples of this type.

The chief features are :—

(*a*) Nearly uniform temperature during the whole night from 7 P.M. to 6 A.M.

(*b*) Slight rise from 6 A.M. until 2 P.M., the epoch of the maximum.

(*c*) Slight fall from 2 P.M. to 7 P.M.

(*d*) Small range or amplitude of variation.

The following gives four-hourly amounts of change at Bombay for the months of July and August in illustration :—

Period.	July.	August.
	°	°
Midnight to 4 A.M.	−0·6	−0·7
4 A.M. to 8 A.M.	+1·1	+1·1
8 A.M. to noon	+2·4	+2·8
Noon to 4 P.M.	−0·4	−0·4
4 P.M. to 8 P.M.	−2·2	−2·4
8 P.M. to midnight	−0·3	−0·4

The following table gives the mean hourly variations of the temperature throughout

the day from the mean of the day during the four seasons of the year for the four divisions of India, *viz.*,—

(1) Tropical Coast.
(2) Tropical Inland.
(3) Extra-Tropical Coast and Assam.
(4) Extra-Tropical Inland.

The data are charted in Plate XIV, Figs. 1 to 20.

TABLE XXXV—*Giving mean hourly variation of temperature in each of four groups of stations for the four seasons of the year.*

	COLD WEATHER PERIOD, JANUARY AND FEBRUARY.				HOT WEATHER PERIOD, MARCH TO MAY.				SOUTH-WEST MONSOON PERIOD, JUNE TO SEPTEMBER.				RETREATING SOUTH-WEST MONSOON PERIOD, OCTOBER TO DECEMBER.			
	Tropical Coast.	Tropical Inland.	Extra-Tropical Coast and Assam.	Extra-Tropical Inland.	Tropical Coast.	Tropical Inland.	Extra-Tropical Coast and Assam.	Extra-Tropical Inland.	Tropical Coast.	Tropical Inland.	Extra-Tropical Coast and Assam.	Extra-Tropical Inland.	Tropical Coast.	Tropical Inland	Extra-Tropical Coast and Assam.	Extra-Tropical Inland.
	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°
Mid.	−3·48	−6·40	−4·31	−5·94	−3·21	−6·27	−3·97	−6·68	−2·02	−3·25	−2·14	−3·65	−2·81	−5·24	−3·92	−6·71
1	−4·11	−7·45	−5·37	−7·05	−3·68	−7·06	−4·63	−7·75	−2·31	−3·64	−2·47	−4·24	−3·28	−5·90	−4·63	−7·6[illegible]
2	−4·61	−8·13	−5·99	−7·73	−4·10	−7·84	−5·13	−8·73	−2·56	−3·94	−2·80	−4·80	−3·59	−6·35	−5·05	−8·1[illegible]
3	−5·08	−8·94	−6·45	−8·36	−4·52	−8·88	−5·64	−9·91	−2·86	−4·30	−3·10	−5·42	−3·90	−7·01	−5·55	−8·6[illegible]
4	−5·59	−10·25	−7·15	−9·39	−4·96	−10·09	−6·25	−11·30	−3·20	−4·72	−3·39	−6·04	−4·31	−7·99	−6·28	−9·7[illegible]
5	−6·12	−11·50	−8·13	−10·70	−5·23	−10·83	−6·75	−12·17	−3·42	−4·97	−3·53	−6·38	−4·67	−8·79	−7·07	−10·9[illegible]
6	−6·24	−11·68	−8·77	−11·31	−4·76	−10·17	−6·57	−11·55	−3·71	−4·66	−3·28	−5·93	−4·52	−8·46	−7·28	−11·1[illegible]
7	−5·10	−9·65	−8·19	−10·02	−3·10	−7·59	−5·28	−8·78	−2·30	−3·57	−3·41	−4·46	−3·25	−6·30	−6·24	−9·0[illegible]
8	−2·5	−5·31	−5·8	−6·38	−0·85	−3·45	−2·90	−4·24	−0·78	−1·64	−1·05	−2·13	−1·10	−2·57	−3·81	−4·76
9	+0·28	+0·01	−2·19	−1·52	+1·42	+1·15	+0·02	+0·83	+0·81	+0·50	+0·52	+0·36	+1·13	+1·62	−0·54	+0·84
10	+2·86	+4·77	+1·85	+3·92	+3·36	+5·06	+2·82	+5·12	+2·16	+2·59	+1·94	+2·66	+3·00	+5·04	+2·69	+5·8[illegible]
11	+4·87	+7·94	+5·25	+7·70	+4·79	+7·79	+4·93	+8·07	+3·14	+4·20	+3·00	+4·31	+4·3[illegible]	+7·14	+5·28	+9·18
Noon	+6·25	+9·69	+7·64	10·15	+5·70	+9·59	+6·50	+9·95	+3·75	+5·36	+3·68	+5·58	+5·1[illegible]	+8·25	+7·05	+11·17
13	+7·07	+11·02	+9·17	+11·68	+6·19	+10·92	+7·58	+11·36	+4·07	+6·13	+4·09	+6·57	+5·57	+9·02	+8·22	+12·54
14	+7·44	+12·28	+10·09	+12·78	+6·24	+11·89	+8·25	+12·46	+4·09	+6·45	+4·28	+7·21	+5·63	+9·63	+8·74	+13·49
15	+7·27	+13·09	+10·27	+13·16	+5·75	+12·03	+8·25	+12·90	+3·79	+6·13	+4·06	+7·29	+5·23	+9·65	+8·46	+13·42
16	+6·32	+12·57	+9·40	+12·08	+4·63	+10·86	+7·29	+12·08	+3·14	+5·09	+3·43	+6·59	+4·27	+8·53	+7·22	+11·57
17	+4·43	+10·12	+7·40	+9·31	+2·97	+8·34	+5·39	+9·7	+2·09	+3·48	+2·41	+5·08	+2·55	+6·21	+5·18	+8·05
18	+2·25	+6·44	+4·71	+5·54	+1·07	+5·07	+3·06	+6·51	+0·89	+1·73	+1·24	+3·13	+1·00	+3·34	+2·90	+3·93
19	+0·59	+2·67	+2·16	+1·99	−0·24	+1·89	+0·92	+3·08	−0·14	+0·23	+0·24	+1·23	−0·11	+0·78	+0·95	+0·52
20	−0·58	−0·29	+0·29	−0·52	−1·06	−0·65	−0·63	+0·17	−0·74	−0·84	−0·53	−0·29	−0·82	−0·90	−0·30	−1·67
21	−1·33	−2·20	−0·90	−2·03	−1·65	−2·53	−1·64	−2·05	−1·16	−1·58	−1·01	−1·39	−1·32	−2·17	−1·10	−2·86
22	−2·01	−3·6	−1·87	−3·31	−2·14	−4·00	−2·43	−3·82	−1·48	−2·17	−1·37	−2·22	−1·84	−3·19	−1·95	−3·98
23	−2·74	−5·11	−3·03	−4·53	−2·67	−5·25	−3·24	−5·36	−1·76	−2·74	−1·75	−2·96	−2·36	−4·37	−2·95	−5·33

The following gives the data showing the proportionate increase of temperature for each hourly interval from 6 A.M. to 2 P.M., during which temperature rises from its minimum to its maximum amount. The amounts are expressed as percentages of the

actual increase of temperature in each hourly period to the total diurnal range for each of the four groups of stations :—

Hour.	Extra-Tropical India.		Tropical India.	
	Inland.	Coast.	Inland.	Coast.
	%	%	%	%
6 to 7 A.M.	+ 9	+ 7	+10	+ 8
7 to 8 A.M.	+17	+17	+18	+17
8 to 9 A.M.	+21	+19	+21	+20
9 to 10 A.M.	+19	+20	+18	+19
10 to 11 A.M.	+13	+15	+12	+15
11 to Noon.	+ 9	+10	+ 8	+11
Noon to 1 P.M.	+ 6	+ 7	+ 6	+ 7
1 to 2 P.M.	+ 4	+ 4	+ 4	+ 2

The data are interesting as they show clearly the very slight differences there are between the relative increase of temperature during the period from 6 A.M. to 2 P.M. in different parts of India. The data in the table are for the mean day of the year.

The following table gives corresponding data for each of the four seasons of the year :—

TABLE XXXVI.

Hour.	Cold weather period (January and February).				Hot weather period (March to May).				South-West monsoon period (June to September).				Retreating South-West monsoon period (October to December).			
	Tropical Inland.	Tropical Coast.	Extra-Tropical Inland.	Extra-Tropical Coast.	Tropical Inland.	Tropical Coast.	Extra-Tropical Inland.	Extra-Tropical Coast.	Tropical Inland.	Tropical Coast.	Extra-Tropical Inland.	Extra-Tropical Coast.	Tropical Inland.	Tropical Coast.	Extra-Tropical Inland.	Extra-Tropical Coast.
	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%
6 to 7 A.M.	+ 8	+ 8	+ 5	+ 3	+11	+14	+11	+ 9	+10	+18	+11	+11	+12	+13	+ 8	+ 7
7 to 8 A.M.	+18	+18	+15	+12	+18	+20	+18	+16	+17	+20	+17	+17	+20	+21	+18	+15
8 to 9 A.M.	+21	+21	+21	+19	+20	+20	+20	+19	+19	+20	+19	+20	+23	+22	+22	+20
9 to 10 A.M.	+19	+19	+21	+21	+17	+17	+17	+19	+18	+17	+16	+18	+19	+18	+20	+20
10 to 11 A.M.	+13	+15	+15	+18	+12	+12	+12	+14	+14	+13	+13	+14	+11	+13	+14	+16
11 to noon	+ 7	+10	+10	+13	+ 8	+ 8	+ 7	+10	+10	+ 8	+ 9	+ 9	+ 6	+ 8	+ 8	+11
Noon to 1 P.M.	+ 5	+ 6	+ 6	+ 8	+ 6	+ 4	+ 6	+ 7	+ 7	+ 4	+ 7	+ 5	+ 4	+ 4	+ 6	+ 7
1 to 2 P.M.	+ 5	+ 3	+ 4	+ 5	+ 4	+ 1	+ 4	+ 4	+ 3	+ 1	+ 5	+ 2	+ 3	+ 1	+ 4	+ 3

The data confirm the results of the preceding table. They indicate that on the average about 80 per cent. of the increase of temperature in the diurnal variation occurs between 7 A.M. and noon, and that the maximum rate of increase is between 8 A.M. and 9 A.M., during which hourly interval it ranges in actual amount between 6° in the interior during the hot season and 1° in the dampest coast districts during the south-west monsoon.

IV.—Constants of the harmonic formulæ or Besselian resolution to four terms. (A) First Component. (*1*) *Data.*—The following table gives a summary of the more important data of the epochs of the maximum and minimum values and of the amplitudes of the first component of the harmonic formulæ representing the diurnal variation of temperature at twenty-seven stations in India :—

TABLE XXXVII.

Area.	Station.	Absolute maximum and minimum during the year.								Year.		
		Maximum value of U_1.	Month of occurrence.	Corresponding value of the phase u_1.	Epoch of absolute maximum.	Minimum value of U_1.	Month of occurrence.	Corresponding value of the phase u_1.	Epoch of absolute minimum.	Value of U_1 for the mean day of the year.	Corresponding value of the phase u_1.	Corresponding epoch.
		°		° ′	H. M.	°		° ′	H. M.	°	° ′	H. M.
Tropical Coast.	Trivandrum . .	6·958	January	232 5	14 32	3·778	July .	243 32	13 46	5·101	240 6	14 0
	Bombay . .	5·540	February	227 18	14 51	1·660	,, .	243 51	13 45	3·930	233 19	14 27
	Aden . . .	4·451	October	242 17	13 51	2·349	January	234 0	14 24	2·908	231 0	14 36
	Rangoon . .	12·240	February	225 10	14 59	2·315	August .	250 19	13 19	6·557	234 41	14 21
	Mean .	7·297	...	231 43	14 33	2·526	...	242 56	13 49	4·624	234 47	14 21
Tropical Inland.	Trichinopoly . .	10·734	February	223 57	15 4	4·831	December	232 39	14 29	7·852	228 43	14 45
	Bellary . . .	11·980	,,	221 4	15 16	6·015	July .	234 4	14 24	8·897	225 5	15 0
	Belgaum . .	12·656	,,	234 19	14 23	2·748	,, .	255 28	12 58	8·196	239 45	14 1
	Poona . . .	14·312	March .	224 6	15 4	3·726	,, .	249 5	13 24	9·877	230 13	14 39
	Nagpur . .	12·760	,,	226 16	14 55	4·041	,, .	234 16	14 23	9·280	227 29	14 50
	Pachmarhi (Hills) .	10·825	January	239 13	14 3	2·082	,, .	209 39	16 2	7·173	235 37	14 18
	Mean .	12·211	...	228 9	14 48	3·907	...	235 52	14 17	8·546	231 9	14 36
Extra-Tropical Coast and Assam.	Chittagong . .	9·536	February	223 13	15 7	2·763	August .	236 39	14 13	5·654	230 18	14 39
	Calcutta . .	8·230	,,	224 25	15 2	2·644	,, .	242 16	13 51	5·588	233 18	14 27
	Kurrachee . .	10·811	November	230 24	14 38	3·452	,, .	243 31	13 46	7·028	233 55	14 24
	Cuttack . .	10·205	January	226 14	14 55	3·471	,, .	242 55	13 48	7·215	233 14	14 28
	Dhubri . . .	9·706	March .	222 17	15 11	2·828	July .	225 52	14 57	5·979	223 10	15 7
	Sibsagar . .	9·390	December	220 3	15 20	4·672	,, .	214 13	15 43	6·537	221 18	15 15
	Mean .	9·647	...	224 26	15 2	3·305	...	234 14	14 23	6·334	229 12	14 43
Extra-Tropical Inland.	Patna . . .	11·958	March .	224 35	15 2	3·460	August .	226 26	14 54	8·261	225 58	14 56
	Hazaribagh . .	10·618	April .	231 51	14 33	3·378	,, .	236 36	14 14	7·649	234 32	14 22
	Allahabad . .	14·180	,, .	231 4	14 36	4·070	July .	231 23	14 34	9·797	232 0	14 32
	Jubbulpore . .	13·552	December	223 55	15 4	3·897	,, .	228 32	14 46	10·033	225 22	14 59
	Lucknow . .	13·930	November	237 26	14 10	4·814	August .	232 31	14 30	10·574	232 4	14 32
	Agra . . .	12·250	April .	224 8	15 4	4·534	,, .	224 22	15 3	9·530	223 15	15 7
	Jaipur . . .	13·790	November	237 30	14 10	5·368	July .	228 1	14 48	10·676	232 30	14 30
	Roorkee . .	13·736	,,	230 7	14 22	5·043	,, .	219 41	15 21	10·479	227 3	14 52
	Deesa . . .	14·901	,,	232 56	14 28	4·964	August .	232 8	15 11	11·207	224 32	15 2
	Lahore . . .	13·592	,,	233 53	14 24	6·278	,, .	227 39	14 49	10·399	229 6	14 44
	Leh . . .	*11·556	September	232 36	14 30	7·987	January	230 8	14 39	9·637	231 6	14 36
	Mean .	13·097	...	230 55	14 35	4·890	...	227 57	14 48	9·840	228 52	14 45

(2) *Amplitude.*—The mean or annual values of the amplitude of the first component vary considerably in amount in different parts of India, depending chiefly upon the latitude of the place and its distance from the sea, and follow very closely the corresponding variations in the mean annual range of temperature.

The mean annual value of the amplitude of the first component is less than 7° for the coast and the Assam stations, and is more than 10° for the stations in North-Western and Central India (Jubbulpore, Jaipur, Deesa, Lucknow, Roorkee and Lahore), and between 7° and 10° for the intermediate stations. The total amplitude of variation is of course double of these amounts and ranges between 7°·9 at Bombay and 10°·2 at Trivandrum and 22°·4 at Deesa and 21° at Roorkee, Lahore, Lucknow and Jaipur.

The monthly values of the amplitude of the first component of the diurnal variation of temperature (U_1) have one maximum and minimum in the course of the year for the greater part of India, including Burma, Assam, Bengal, Bihar, Chota Nagpur, Orissa and the Peninsula (excepting the extreme south so far as it is represented by Trichinopoly.) They have, on the other hand, two maxima and minima values in the North-Western Provinces, Rajputana, the Punjab, Sind, Central India and the northern half of the Central Provinces, or at all stations to the north of the Vindhyas and west of the province of Bihar.

The minimum monthly values of U_1 occur in July or August over nearly the whole of India and the maximum monthly values in the dry monsoon in November in North-Western India, from January to March in North-Eastern and Southern India and in April in the area represented by the stations of Agra, Allahabad and Hazaribagh. The months of minimum values of U_1 correspond with the months of smallest range, and, for maximum with the greatest range of temperature. These two epochs correspond chiefly to the contrast at each station between the driest and dampest periods, and hence to the character of the prevailing winds, and are not solely related to the intensity of solar radiation.

Over the greater part of India, including all India except North-Western and Southern India, the general march of the weather of the wet and dry seasons is similar. It is interrupted locally in North-Western India by a period of occasional cloudy and showery weather from December or January to March, and in Southern India by a more or less cloudy weather with much rain during November or December.

In the first area the effect is to displace the absolute maximum to November, the driest and least cloudy month, and to give a very feeble secondary minimum in January or February and a secondary maximum in March or April.

A reference to Plates X and XI will show that this feature is very faintly exhibited in the curves representing the mean annual variation of temperature of all the stations in North-Western India. It is very clearly shown in Fig. 11, Plate LXV, giving the annual variation of U_1 for Lahore.

In Southern India (more especially the central districts as represented by Trichinopoly) the absolute minimum is in December, a period of heavy and general rainfall in that part of India, and the absolute maximum is in February, a month of low humidity and also of the least influence of the neighbouring seas. The secondary minimum is fairly well marked, occurring at the commencement of the rainy season in June when Southern India receives a moderate and fairly general burst of rain. The secondary maximum is in September, just before the retreating south-west monsoon begins to give general rain in the Peninsula.

The double variation is distinctly shown in the curve giving the annual variation of the diurnal range of temperature at Trichinopoly, (*vide* Fig. 10, Plate XIII).

The following table gives the greatest and least monthly values of U_1 for comparison :—

TABLE XXXVIII.

STATION.	Maximum monthly value of U_1.	Minimum monthly value of U_1.	Ratio of maximum to minimum value of U_1.
Sibsagar	$9^\circ.39$	$4^\circ.67$	$2^\circ.0$
Goalpara	8·86	3·02	2·9
Dhubri	9·71	2·83	3·4
Hazaribagh	10·62	3·38	3·2
Patna	11·96	3·46	3·4
Allahabad	14·18	4·07	3·5
Lucknow	13·93	4·81	2·9
Agra	12·25	4·53	2·7
Roorkee	13·74	5·04	2·7
Lahore	13·59	6·28	3·0
Chittagong	9·54	2·77	3·5
Cuttack	10·21	3·47	3·0
Jubbulpore	13·55	3·90	3·5
Nagpur	12·76	4·04	3·2
Belgaum	12·66	2·75	4·6
Deesa	14·90	4·96	3·5
Poona	14·31	3·73	3·8
Bellary	11·98	6·02	1·8
Rangoon	12·24	2·32	5·0
Jaipur	13·79	5·37	2·6

(3) *Epochs of the maximum and minimum phases.*—The more important features of the epochs of the maximum and minimum phases of the first component of the diurnal variation of temperature on the mean day of the year are as follows :—

(1) The mean epoch of the maximum of the first component in Extra-Tropical India Inland is 2-45 P.M. and in Tropical Inland is 2-36 P.M. It is hence almost identical with the corresponding epoch of the complete oscillation. It ranges between 2-22 P.M. at Hazaribagh and 3-2 P.M. at Deesa and (perhaps) 3-7 P.M. at Agra.

(2) It is slightly earlier at the coast stations than at the inland stations. It is actually latest in the Assam Valley where the distribution of cloud follows a different law from the remainder of India. A reference to the cloud curves in Plates XLI and XLIII will show that while the maximum amount of cloud occurs in the afternoon hours generally in India, it is in the morning hours in Assam, where also the cloud proportion gradually decreases during the afternoon.

It hence follows that the first component gives the most important features of the diurnal variation of temperature due to the sun's heating action and that its maximum corresponds very closely to that of the maximum of the complete variation but is at most stations a few minutes later. The following gives a few examples for the mean day of the year:—

Station.	Epoch of maximum of first component (a).		Epoch of maximum of complete variation (b).		Difference (a)—(b).
	H.	M.	H.	M.	M.
Patna	14	56	14	44	12
Allahabad	14	32	14	23	9
Agra	15	7	15	3	4
Roorkee	14	52	14	34	18
Lahore	14	44	14	36	8
Deesa	15	2	14	56	6

In Northern India the epoch of the maximum of the first component is, as a rule, earliest in the day in October and November when skies are most serene and free from cloud and latest in January and February in both of which months there is much cloud. The range of variation during the year of the monthly epochs of the maximum of this component average approximately one hour.

(B) Second Component.—(*1*) *Data.*—The following table gives a summary of the most important data of the epochs of the maxima and minima phases and of the amplitudes of the second component at 27 stations in India:—

TABLE XXXIX.

Area.	Station.	Absolute maximum and minimum during the year.								Year.		
		Maximum value of U_2.	Month of occurrence.	Corresponding value of the phase u_2.	Epoch of absolute maximum (A.M. and P.M.)	Minimum value of U_2	Month of occurrence.	Corresponding value of the phase u_2.	Epoch of absolute minimum (A.M. and P.M.)	Value of U_2 for the mean day of the year.	Corresponding value of the phase u_2.	Corresponding epoch (A.M. and P.M.)
		°		° ′	H. M.	°		° ′	H. M.	°	° ′	H. M.
Tropical Coast.	Trivandrum	1·820	February	78 49	0 22	0·979	July	78 41	0 23	1·354	82 46	0 14
	Bombay	1·770	January	52 7	1 16	0·640	,,	68 2	0 44	1·230	57 15	1 5
	Aden	1·638	October	100 33	11 39	0·381	,,	94 31	11 51	0·852	77 6	0 26
	Rangoon	3·989	February	46 38	1 27	0·909	August	81 47	0 16	2·079	59 59	1 0
	Mean	2·304		69 32		0·727		80 45		1·379	69 17	0 41
Tropical Inland.	Trichinopoly	2·411	May	44 30	1 31	1·509	November	76 59	0 26	1·918	50 30	1 19
	Bellary	2·659	February	46 13	1 28	1·563	June	43 42	1 33	2·026	52 37	1 15
	Belgaum	3·859	April	68 5	0 44	1·135	August	67 44	0 45	2·379	66 59	0 46
	Poona	3·362	February	55 47	1 8	1·243	July	78 52	0 22	2·409	67 48	0 44
	Nagpur	2·972	December	53 12	1 14	0·942	,,	70 48	0 38	2·081	61 35	0 57
	Pachmarhi Hills	2·709	,,	73 42	0 33	0·522	August	69 50	0 40	1·655	67 37	0 45
	Mean	2·995		56 55		1·152		57 59		2·078	61 11	0 58

TABLE XXXIX—*concld.*

Area.	Station.	Absolute maximum and minimum during the year.								Year.		
		Maximum value of U_2.	Month of occurrence.	Corresponding value of the phase u_2.	Epoch of absolute maximum (A.M. and P.M.)	Minimum value of U_2.	Month of occurrence.	Corresponding value of the phase u_2.	Epoch of absolute minimum (A.M. and P.M.)	Value of U_2 for the mean day of the year.	Corresponding value of the phase u_2.	Corresponding epoch (A.M. and P.M.)
		°		° ′	H. M.	°		° ′	H. M.	°	° ′	H. M.
Extra-Tropical Coast and Assam.	Chittagong	3·015	February	64 27	0 51	0·730	June	89 13	0 2	1·765	73 12	0 34
	Calcutta	2·427	January	34 56	1 50	0·663	July	78 41	0 23	1·467	49 9	1 22
	Kurrachee	3·564	November	71 31	0 37	1·052	August	65 52	0 48	2·346	69 1	0 42
	Cuttack	3·248	April	47 7	1 26	1·018	September	82 40	0 15	2·186	53 11	1 14
	Dhubri	2·490	February	38 48	1 42	0·437	July	74 3	0 32	1·506	44 12	1 32
	Sibsagar	2·633	December	36 48	1 46	0·868	„	28 13	2 4	1·568	39 14	1 42
	Mean	2·896		48 56		0·795		69 47		1·806	54 40	1 11
Extra-Tropical Inland.	Patna	2·881	December	59 20	1 1	0·637	August	59 32	1 1	1·935	60 9	1 0
	Hazaribagh	2·779	January	54 23	1 11	0·908	„	73 22	0 33	1·907	65 51	0 48
	Allahabad	4·330	December	53 16	1 13	0·973	July	56 19	1 7	2·849	56 56	1 6
	Jubbulpore	3·458	„	54 39	1 11	0·919	„	45 0	1 30	2·219	59 23	1 1
	Lucknow	4·144	„	58 25	1 3	1·035	„	48 55	1 22	2·458	57 48	1 4
	Agra	3·981	November	48 28	1 23	0·943	„	55 48	1 8	2·447	51 18	1 17
	Jaipur	4·212	December	53 36	1 13	1·168	„	56 10	1 8	2·596	57 6	1 6
	Roorkee	3·997	November	59 58	1 0	0·790	„	38 19	1 43	2·389	57 18	1 5
	Deesa	4·158	December	68 33	0 43	0·921	„	41 29	1 37	2·458	65 54	0 48
	Lahore	4·591	November	55 12	1 10	1·290	„	56 4	1 8	2·676	52 45	1 15
	Leh	3·431	„	60 18	0 59	1·952	June	60 33	0 59	2·657	62 11	0 36
	Mean	3·815		56 55		1·040		53 46		2·420	58 47	1 2

(2) *Amplitude.*—The more noteworthy features of the amplitude of this component are as follows:—

(1) The amplitude of the second component increases slightly on proceeding from the coast to the interior in Northern India and is actually largest at Allahabad. It is practically uniform in the Peninsula except in the Deccan where it is slightly larger than in the coast districts. It averages 2°·4 for Extra-Tropical India, and is very approximately one-fourth of the amplitude of the first component.

(2) The ratio of the amplitude of the second component to that of the first varies to some extent throughout the year. The ratio is least in the rains when it averages one-sixth and greatest in the cold weather when it is about one-third.

(3) The second component, relatively to the first, is most important in dry weather and least important in humid rainy weather. It is also generally more important or of relatively larger amount at stations on the coast than at stations in the interior. The monthly values are, as a rule, greatest in November and December and least in July and August.

(4) The monthly values of the amplitude of the second component have a single maximum and minimum for all stations in Northern and Central India and the Central Provinces, with the exception of the Assam stations and perhaps Kurrachee and Allahabad. It is noteworthy that all stations in North-Western and Central India which have two maxima and minima values of the amplitude of the first component have only one maximum and minimum for the second component.

(5) The monthly values of the amplitude of the second component have two (and in one case three) maxima and minima values in the course of the year at the Assam and Central and South Peninsular stations at all of which stations the monthly values of the amplitude of the first component have only one value. There is hence in this feature a marked contrast between the first and second components.

(6) The ratio of the maximum to the minimum value varies considerably from station to station, ranging in Northern India between 3·1 at Hazaribagh and 5·1 at Roorkee. The relative variation is, as a rule, greater at the inland than at the coast stations.

(7) The monthly values of the ratio of the amplitude of the second component to that of the first component (*i.e.*, U_2/U_1) are fairly constant at each station throughout the year. An important feature is that this ratio is greatest for the coast stations (averaging ·31) and decreases into the interior and is least for stations in Upper India, more especially the following :— Roorkee (·23), Bellary (·23), Nagpur (·22), Jubbulpore (·22), and Deesa (·22). This list of stations suggests that distance from the sea coast is an important factor in modifying this ratio.

(8) The ratio of U_2/U_1 for the Assam stations is the same as for Lahore and Agra, and hence it does not depend upon humidity. This is confirmed by examination of the monthly values of the ratios of U_2 to U_1.

(3) *Maximum and minimum epochs of the second component.*—The following are the more important features of this element of the second component :—

(1) The epoch of the second maximum phase on the mean day of the year in Extra-Tropical India Inland is 1-2 P.M. and the range of variation 29 minutes. The epoch is earliest at Deesa and Hazaribagh (0-48 P.M.) and latest at Lahore (1-15 P.M.) and perhaps Agra (1-17 P.M.).

(2) The mean epoch of the second maximum phase in Tropical India Inland is 0-58 P.M., and is hence a few minutes earlier than in Extra-Tropical India Inland. It is earliest at Poona (0-44 P.M.) and latest at Trichinopoly (1-19 P.M.).

(3) The maximum epochs are in Northern India generally latest in the cold-weather month of January or in the rainy season months (June to August). They are earliest in the hot-weather months of April and May or in October. In Tropical India the epochs of the maximum are as a rule earliest in the rains and latest in the dry months of January and February. The range of variation for each station averages about one hour.

The second component has two maxima values during the day at about 1 A.M. and 1 P.M. and two minima values at 7 A.M. and 7 P.M. The effect of the combination of this with that of the first component is to increase the mid-day temperature, to slightly displace the maximum towards noon and the minimum towards the early morning, to increase the rise of temperature between 6 A.M. and 1 P.M. and the fall from 1 P.M. to 6 P.M. and to diminish the fall during the night hours. It tends to give increased variation by day and diminished by night, and the combination of the two gives a curve differing very slightly from the actual curve of total variation.

(C). Third Component.—(1) *Data.*—The following table gives a summary of the more important data of the epochs of the maximum and minimum and of the amplitudes of the third component at 27 stations in India:—

TABLE XL.

Area.	Station.	Absolute maximum and minimum during the year.								Year.		
		Maximum value of U_3	Month of occurrence.	Corresponding value of the phase v_3.	Epoch of second absolute maximum of day.	Minimum value of U_3.	Month of occurrence.	Corresponding value of the phase v_3	Epoch of second absolute minimum of day.	Value of U_3 for the mean day of the year.	Corresponding value of the phase v_3.	Corresponding epoch of second maximum of day.
		°		° ′	H. M.	°		° ′	H. M.	°	° ′	H. M.
Tropical Coast.	Trivandrum	0·519	February	17 1	9 37	0·236	August	19 35	9 34	0·376	23 41	9 28
	Bombay	0·360	April May	75 4 88 10	8 20 8 3	0·040	July	139 30	6 54	0·070	102 38	7 43
	Aden	0·677	August	343 42	10 22	0·082	January	284 2	11 41	0·253	18 26	9 35
	Rangoon	0·574	March	234 56	4 47	0·058	June	329 2	10 41	0·120	318 22	10 56
	Mean	0·533		169 19		0·104		193 2		0·205	115 47	9 26
Tropical Inland.	Trichinopoly	0·741	March	31 46	9 18	0·086	October	35 32	9 13	0·359	30 8	9 20
	Bellary	1·275	February	4 30	9 54	0·067	July	116 34	7 25	0·503	17 21	9 37
	Belgaum	1·225	February	28 15	9 23	0·051	August	78 41	8 15	0·484	29 45	9 20
	Poona	1·729	March	2 59	9 55	0·054	July	158 12	6 29	0·709	1 37	9 58
	Nagpur	1·435	April	31 2	9 19	0·238	June	22 15	9 31	0·838	17 21	9 37
	Pachmarhi Hills	1·439	February	34 15	9 15	0·089	August	206 34	5 24	0·817	39 32	9 17
	Mean	1·307		22 8		0·098		102 58		0·618	22 37	9 30
Extra-Tropical Coast and Assam.	Chittagong	0·779	February	303 29	11 15	0·143	September	12 6	9 44	0·260	337 23	10 30
	Calcutta	0·498	April	51 31	8 51	0·182	August	9 28	9 47	0·322	29 45	9 20
	Kurrachee	0·865	December	303 41	11 15	0·100	September	5 43	9 52	0·391	320 12	10 53
	Cuttack	0·369	January	327 10	10 44	0·100	June	53 8	8 49	0·133	13 0	9 43
	Dhubri	0·466	April	30 58	9 19	0·040	September	90 0	8 0	0·104	16 42	9 38
	Sibsagar	0·428	May	52 39	8 50	0·136	January	189 11	5 48	0·177	55 50	8 47
	Mean	0·568		178 15		0·117		59 56		0·231	128 49	9 49

TABLE XL—*concld.*

Area.	Station.	Absolute maximum and minimum during the year.								Year.		
		Maximum value of U_3.	Month of occurrence.	Corresponding value of the phase u_3.	Epoch of second absolute maximum of day.	Minimum value of U_3.	Month of occurrence.	Corresponding value of the phase u_3.	Epoch of second absolute minimum of day.	Value of U_3 for the mean day of the year.	Corresponding value of the phase u_3.	Corresponding epoch of second maximum of day.
		°		° ′	H. M.	°		° ′	H. M.	°	° ′	H. M.
Extra Tropical Inland.	Patna	0·990	April	30 1	9 20	0·217	September	50 26	8 52	0·498	18 0	9 36
	Hazaribagh	1·493	"	25 49	9 26	0·191	"	42 53	9 3	0·622	27 48	9 23
	Allahabad	1·503	"	25 12	9 27	0·085	October	20 34	9 32	0·412	14 2	9 41
	Jubbulpore	1·202	"	7 39	9 50	0·139	August	59 45	8 40	0·591	4 51	9 54
	Lucknow	1·477	"	28 18	9 23	0·309	"	24 54	9 27	0·778	27 33	9 23
	Agra	1·301	"	12 26	9 43	0·264	"	24 37	9 27	0·682	10 59	9 44
	Jaipur	1·742	"	23 20	9 29	0·241	"	41 38	9 4	0·913	24 36	9 27
	Roorkee	1·330	"	23 29	9 28	0·481	September	43 19	9 3	0·521	3 18	9 56
	Deesa	1·440	November	3 35	9 55	0·050	July	53 8	8 49	0·798	12 18	9 44
	Lahore	1·167	May	24 49	9 27	0·371	"	27 15	9 24	0·536	8 35	9 49
	Leh	0·990	June	56 57	8 44	0·134	December	276 34	11 24	0·410	46 58	8 58
	Mean	1·330		23 47		0·226		62 17		0·615	18 5	9 36

(2) *Amplitude.*—The amplitude of the third component of the variation of temperature of the mean day of the year is small in amount compared with those of the first and second components. It is very small for stations on and near the sea coast and in Assam, averaging 0·22°, and ranges between 0·3° and 0·9° for stations in the interior of India.

The monthly values of the amplitude of the third component vary very largely and somewhat irregularly. As a rule, they are largest in the hot weather months of March, April and May and are smallest in the rainy months, chiefly in July and August. The chief feature is the very great contrast between the maximum and minimum values of the amplitude in many cases. The following gives a few examples :—

Station.	Maximum value of U_3.	Month of occurrence.	Minimum value of U_3.	Month of occurrence.
Calcutta	0·498	April	0·182	August
Allahabad	1·503	April	0·085	October
Deesa	1·440	November	0·050	July
Belgaum	1·225	February	0·051	August
Trichinopoly	0·741	March	0·086	October
Rangoon	0·574	March	0·058	June
Nagpur	1·435	April	0·238	June

(3) *Epochs of the maximum and minimum values.*—These vary somewhat from station to station for the mean day of the year as shown by the following table:—

Station.	Mean value of u_3		Mean epoch of second maximum of day.	
	°	′	A.	M.
Calcutta	20	45	9	20
Allahabad	14	2	9	41
Lahore	8	35	9	48
Deesa	12	18	9	44
Jaipur	24	36	9	27
Nagpur	17	21	9	37
Belgaum	29	45	9	20
Trichinopoly	30	8	9	20
Rangoon	318	22	10	56
Roorkee	3	18	9	56
Sibsagar	55	50	8	46

It may be noted that there are three maximum epochs of the day at eight hours' intervals.

The epochs of the maximum and minimum values vary very largely from month to month and the range in the time of occurrence of the epochs, as estimated from the monthly values, is, in some cases, as large as three or even four hours.

(D). Fourth Component.—(1) *Data.*—The following table gives a summary of the more important data of the epochs of the maximum and minimum phases and of the amplitudes of the fourth component at 27 stations in India:—

TABLE XLI.

Area.	Station.	Absolute maximum and minimum during the year.								Year.		
		Maximum value of U_4.	Month of occurrence.	Corresponding value of the phase u_4.	Epoch of absolute maximum.	Minimum value of U_4.	Month of occurrence.	Corresponding value of the phase u_4.	Epoch of absolute minimum.	Value of U_4 for the mean day of the year.	Corresponding value of the phase u_4.	Corresponding epoch.
		°		° ′	H. M.	°		° ′	H. M.	°	° ′	H. M.
Tropical Coast.	Trivandrum	0·405	January and March	226 0 238 10	3 44 3 42	0·223	July	247 59	3 22	0·295	244 28	3 26
	Bombay	0·410	March	250 3	3 20	0·080	„	290 2	2 40	0·260	260 21	3 10
	Aden	0·453	October	223 13	3 47	0·114	May.	254 45	3 15	0·239	213 1	3 57
	Rangoon	0·727	January.	211 30	3 58	0·070	July	270 0	3 0	0·333	221 21	3 49
	Mean	0·409		229 13		0·122		265 42		0·282	234 48	3 36

TABLE XLI—*concld.*

Area.	Station.	Absolute maximum and minimum during the year.								Year.		
		Maximum value of U_4.	Month of occurrence.	Corresponding value of the phase u_4.	Epoch of absolute maximum.	Minimum value of U_4.	Month of occurrence.	Corresponding value of the phase u_4.	Epoch of absolute minimum.	Value of U_4 for the mean day of the year.	Corresponding value of the phase u_4.	Corresponding epoch.
		°		° ′	H. M.	°		° ′	H. M.	°	° ′	H. M.
Tropical Inland.	Trichinopoly .	0·581	February .	220 49	3 49	0·263	July . .	229 38	3 40	0·392	232 15	3 38
	Bellary . .	0·659	January .	210 4	4 0	0·202	,, . .	261 28	3 9	0·425	228 49	3 41
	Belgaum . .	1·104	,, .	222 4	3 43	0·143	August .	245 13	3 25	0·541	236 19	3 34
	Poona . .	1·039	,, .	203 51	4 6	0·128	July . .	231 20	3 39	0·573	225 42	3 44
	Nagpur . .	0·982	February .	215 28	3 55	0·089	,, . .	206 34	4 3	0·492	232 26	3 38
	Pachmarhi Hills .	1·253	January .	222 5	3 48	0·103	May . .	209 3	4 1	0·584	231 57	3 48
	Mean .	0·936		215 44		0·155		230 33		0·501	231 15	3 41
Extra-Tropical Coast and Assam.	Chittagong . .	0·637	February .	202 8	4 8	0·100	July . .	233 8	3 37	0·382	222 53	3 47
	Calcutta . .	0·800	,, .	193 0	4 17	0·108	,, . .	236 18	3 34	0·394	215 42	3 54
	Kurrachee . .	0·748	November.	232 3	3 38	0·158	June . .	235 18	3 35	0·425	221 11	3 49
	Cuttack . .	0·943	January .	199 12	4 11	0·136	,, . .	233 58	3 36	0·448	218 40	3 51
	Dhubri . .	0·509	February .	199 30	4 10	0·078	May. .	129 48	5 20	0·234	199 59	4 10
	Sibsagar . .	0·505	,, .	223 13	3 47	0·113	July . .	206 20	4 4	0·293	230 11	3 40
	Mean .	0·690		208 11		0·116		212 28		0·363	218 6	3 52
Extra Tropical Inland.	Patna . . .	0·756	November.	228 31	3 41	0·103	July . .	249 27	3 21	0·467	223 24	3 47
	Hazaribagh .	0·835	February .	228 12	3 42	0·130	,, . .	202 37	4 7	0·530	234 13	3 36
	Allahabad . .	0·980	,, .	207 21	4 3	0·142	,, . .	219 17	3 51	0·623	223 42	3 46
	Jubbulpore .	0·918	November .	218 22	3 52	0·072	August .	213 42	3 56	0·511	214 37	3 55
	Lucknow . .	1·260	,, .	231 46	3 38	0·156	,, .	219 48	3 50	0·701	227 53	3 42
	Agra . . .	0·955	,, .	212 34	3 57	0·130	July . .	202 37	4 7	0·608	212 54	3 57
	Jaipur . .	1·619	,, .	225 45	3 44	0·149	,, . .	227 44	3 42	0·792	223 59	3 46
	Roorkee . .	1·002	October .	233 56	3 36	0·121	,, . .	155 33	4 54	0·490	219 12	3 51
	Deesa . .	1·542	December .	210 23	4 0	0·091	,, . .	263 40	3 6	0·757	225 32	3 44
	Lahore . .	1·196	November.	223 18	3 47	0·124	,, . .	194 2	4 16	0·581	220 49	3 49
	Leh . . .	0·877	September	244 19	3 26	0·330	June .	255 53	3 14	0·570	248 23	3 22
	Mean .	1·096		224 2		0·141		218 35		0·603	224 58	3 45

(2) *Amplitude.*—The chief features of this element of the fourth component are as follows :—

(1) The annual values of the amplitude are smallest for the coast stations and increase on proceeding into the interior. They are greatest for Jaipur (0·79°) and Deesa (0·76°). They follow the same law in this respect as the annual values of the amplitude of the third component. The values for the coast stations are greater for the fourth than for the third component whereas they differ little in amount for inland stations. The

values do not differ much for stations in the interior of the Peninsula but are on the whole greatest for the West Deccan stations and at Pachmarhi.

(2) The monthly values of the amplitude of the fourth component are usually greatest in the dry cool weather and least in the rains. The following gives a few examples :—

STATION.	Maximum value of U_4.	Month of occurrence.	Minimum value of U_4.	Month of occurrence.
Calcutta . .	0·800°	February	0·108°	July.
Allahabad . .	0·980	"	0·142	"
Lahore . .	1·196	November	0·124	"
Jaipur . .	1·619	"	0·149	"
Deesa . .	1·542	December	0·091	"
Nagpur . .	0·982	February	0·089	"
Belgaum . .	1·104	January	0·143	August.
Trichinopoly .	0·581	February	0·263	July.
Rangoon . .	0·727	January	0·070	"

(3) It is very noteworthy that the monthly values have only one maximum and minimum value at the great majority of stations, but at several stations in North-Western India, including Allahabad, Roorkee and Kurrachee, they have two maxima and minima values. The absolute maximum and minimum values are in November and July (or August) and the secondary maximum and minimum in the cold weather months of January, February or March. This feature of the fourth component agrees closely with a similar feature in the first component.

(3) *The epochs of the maximum and minimum phases of the fourth component.*—The most noteworthy feature of this element is that the epoch for the mean day of the year differs very slightly over the whole of India. There are of course four maximum epochs in the diurnal period. The following gives them :—

STATION.	MEAN EPOCH OF U_4 ON THE MEAN DAY OF THE YEAR.			
	A.M. and P.M.		A.M. and P.M.	
Kurrachee	3	49	9	49
Lahore	3	49	9	49
Deesa	3	44	9	44
Agra	3	57	9	57
Lucknow	3	42	9	42
Allahabad	3	46	9	46

Station.	Mean epoch of u_4 on the mean day of the year.			
	A.M. and P.M.		A.M. and P.M.	
Jaipur	3	46	9	46
Hazaribagh	3	36	9	36
Patna	3	47	9	47
Calcutta	3	54	9	54
Cuttack	3	51	9	51
Jubbulpore	3	55	9	55
Nagpur	3	38	9	38
Poona	3	44	9	44
Belgaum	3	34	9	34
Bellary	3	41	9	41
Trichinopoly	3	38	9	38
Rangoon	3	49	9	49

It will be seen that these four epochs agree approximately with the minimum and maximum epochs of pressure.

(2) The epochs vary very slightly from month to month. They are, as a rule, slightly earlier in the hot weather and rains than in the cold weather. The range of variation during the year, as given by the monthly values of the epochs, is very small, almost as small as in the maximum epoch of the first component. The following gives the range in a few cases :—

Station.	Range of variation in the epoch u_4.	
	H.	M.
Calcutta	0	57
Hazaribagh	0	49
Allahabad	0	40
Lahore	0	57
Deesa	0	56
Jaipur	1	18
Belgaum	0	40
Trichinopoly	0	58

In each memoir of the hourly observations of 28 stations in India the diurnal variation of temperature has been analysed by Bessel's method and expressed as the sum of four harmonic elements of periods of 24, 12, 8, and 6 hours respectively. The constants of these four harmonic elements, *viz.*, the semi-amplitudes and the phases of the angular values of the epochs at midnight are given in tables in each memoir.

An interesting and important question is to determine whether the resolution into four harmonic elements or constituents is purely mathematical, or whether the constituents represent real and independent factors due to separate or separable causes or actions, and having periods of the same length as the corresponding temperature constituents or elements.

The harmonic resolution is applied chiefly to the annual and to the diurnal variations of temperature. The chief features or actions determining the annual variation of temperature are:—

(1) The varying intensity of the solar heating power as dependent upon the varying elevation of the sun.

(2) The varying amount of absorption of the solar heat by the atmosphere and earth's surface as dependent upon the amount of cloud and humidity of the air.

The first factor has a continuous variation of twelve months' period. A mathematical expression for this element will be found in Ferrels' Meteorology, pages 78 and 79, expressed in a series of harmonic functions of the time; it is—

$$T = A_0 \{C_0 + C_1 \cos(nt - c_1) + C_2 \cos(2nt - c_2) + \text{etc}\}$$

in which the constants have the following values in Lats., 0°, 10°, 20°, 30° and 40°

LATITUDE	C_n AND c_n.						
	C_0.	C_1.	C_2.	C_4	c_1.	c_2.	c_4.
					° ′	° ′	° ′
0°	3053	·0101	·0131	·0001	0 30	159 8	318 24
10°	·3010	·0247	0136	·0001	166 22	160 4	318 24
20°	2885	·0585	·0128	·0001	167 46	161 4	318 24
30°	·2682	·0969	·0107	·0000	168 30	162 31	...
40°	·2411	·1200	·0069	·0001	168 50	165 54	138 24

C_2 and C_4 are very small and of no importance.

The second factor depends upon conditions which determine the amount of absorption of the solar radiation through the earth's atmosphere. For example, in very cloudy

weather the larger portion of the sun's heat is absorbed by the clouds (*i.e.*, by the small particles or vesicles of condensed aqueous vapour), and a much smaller proportion is hence absorbed by the lower strata of the atmosphere and by the earth's surface, which again is partly communicated to the lowest strata. These conditions hence affect largely the amount of absorption, and hence the variation of the temperature of the lower strata of the atmosphere over the interior of India.

The year in India may be divided into two nearly equal periods of contrasted conditions. In the first period, from October or November to May, the air is very dry and there is little cloud, and hence the amount of absorption of solar radiation is small, but probably increases to some extent from January to May. During the second period, that of the wet season, the atmosphere is largely charged with aqueous vapour and there is much cloud. The greater part of the solar radiation is hence absorbed before it reaches the ground surface. There is hence an annual variation of these factors which will evidently produce a corresponding variation of temperature. The variation does not however conform to a simple harmonic type, as the transition from the dry to the humid conditions is usually very rapid, approaching in character to a discontinuous change.

It is however probable from *à priori* considerations that in India (more especially the Peninsula) the resolution by Bessels' method will give annual and semi-annual variations of large or moderate amplitude and harmonic components of 4 and 3 months of small amplitude. This is confirmed by actual data given below for the constants of the harmonic formulæ representing the annual variation of temperature at eight representative stations:—

Station.	Annual variation of												
	Amplitudes.				Phases.								
	U_1	U_2	U_3	U_4	u_1		u_2		u_3		u_4		
	°	°	°	°	°	'	°	'	°	'	°	'
Lahore	19·638	2·971	1·131	1·070	280	57	272	47	45	0	178	14
Allahabad	15·385	4·946	0·960	0·706	292	37	272	11	69	42	202	56
Nagpur	9·795	5·198	1·633	0·793	315	41	272	42	91	45	344	47
Calcutta	9·615	4·348	0·296	0·622	287	6	281	41	321	51	116	9
Bellary	6·383	3·819	0·224	0·433	326	35	287	8	131	56	30	3
Bombay	3·699	2·540	0·184	0·224	287	55	240	0	354	42	333	26
Belgaum	3·411	2·968	0·154	0·351	356	6	268	53	310	31	34	41
Rangoon	2·430	2·818	0·569	0·421	315	32	268	14	238	9	71	44

An examination of the preceding data suggests the following inferences:—

(1) The amplitude of the annual term (U_1) increases largely in amount in proceeding from coast stations to the most interior stations in India. It is, for instance, nearly six times as large for Lahore as for Bombay and eight times as large as for Rangoon.

(2) The amplitude of the semi-annual component U_2 varies to a much smaller extent than the annual, the maximum being less than two times as great as the minimum. The magnitude of the amplitude does not appear to depend directly upon latitude or upon distance from the sea.

(3) The amplitudes of the third and fourth components are small at stations on or not far from the coast. They are moderate in amount at the more inland stations. Hence the chief factors in determining their values are probably the same as for U_1.

(4) The maximum epochs of the first, third and fourth components vary very considerably from station to station; thus the range of the epoch of the first component (from the coast to the interior station of Leh) is $2\frac{1}{3}$ months, corresponding to the period of translation of the area of highest temperature from the Deccan in February and March to Upper India in May and June. The ranges of u_3 and u_4 are equally large.

(5) The maximum epoch of the second component is, on the other hand, remarkably constant at these stations, being little more than half a month.

A consideration of these facts, and of the chief features of the two actions stated above, suggests that the second component chiefly represents the regular variation from the dry to the wet season over India, as it is remarkably constant and occurs about the same period over the whole of India. On the other hand, the first component chiefly represents the variation of the first action, *viz.*, the annual variation of the solar radiant heat due to the annual changes of the sun's meridian altitude.

The factors determining the diurnal variation of temperature are more numerous and complex. The most important are the following:—

(1) The heating of the air directly by absorption of the solar radiation in its passage towards the earth's surface. The absorbing power of the air is small and hence the variation of the temperature due to this cause is small. It is also a discontinuous process lasting about 12 hours daily.

(2) The exchange of heat by conduction with the earth's surface. During the greater part of the day the air receives heat from the earth, and usually during a part of the night it loses heat due to this mutual action.

(3) The action of convection currents which redistribute throughout the mass the heat received from the earth's surface. This process, by introducing fresh masses of air into contact with the earth's surface, tends to withdraw a larger part of the heat absorbed by the earth than would be the case if there were no convection currents. This is hence a continuous process having a maximum effect about the hottest time of the day, but practically restricted to the day hours.

(4) The presence of varying amounts of cloud in the middle or upper atmosphere. This modifies largely the proportion of heat received by the earth's surface and the lower strata of the atmosphere from the sun. The variation of cloud has a diurnal periodicity which undoubtedly modifies slightly the diurnal variation of temperature.

(5) The effect of rainfall. When the solar radiation falls upon a damp or wet surface, it is chiefly or almost entirely utilized in evaporating the contained moisture, and there is little change of temperature whilst this process is going on. Hence, in continued dry weather in the interior of India, the solar radiation is utilized chiefly in heating the earth's surface and the adjacent air, whilst in continued damp showery weather as in the south-west monsoon or after heavy general rain in the dry season it is chiefly utilized in the work of evaporation and there is little change of temperature of the earth's surface. The lower air is, under these conditions, only slightly warmed during the day and chiefly by the direct action of the sun.

The actual variation is hence the resultant of the variations due to these separate actions and conditions. Two at least of these actions are continuous and have a 24 hourly period. The remaining three are discontinuous and two of them have a period of about 12 hours, the actions being restricted to the day hours. The Besselian resolution of the diurnal variation of temperature (as given in the memoirs) furnishes harmonic elements of 24, 12, 8 and 6 hours period. The two first elements only correspond to periods of real action, but the slightest consideration shows that the two elements are not independent and do not correspond to separate actions or factors. The Besselian formula in this case, hence, gives a mathematical resolution which has a partial (or mixed) physical basis for two of its elements.

The question of whether the third and fourth components have any relation to corresponding elements in the diurnal variation of cloud, etc., is readily solved by a comparison of these elements. So far as can be judged from such a comparison there is no direct relation between these elements and hence any effect due to the amount of cloud, etc. (as given by its Besselian resolution), is obscured by terms of the same period in the Besselian resolution of the other factors.

An examination of the constants of the harmonic formulæ however furnishes a number of interesting conclusions, in part due to the fact that in consequence of the almost unvarying length of the day proper (sunrise to sunset) in India the general form of the temperature curves is practically the same throughout the year, the only important variations being, as already pointed out, those due to—

(1) Varying intensity of the solar action throughout the year. This is small in amount in Southern India and moderate in Northern India.

(2) Varying effect of the solar intensity due to variations in (*a*) amount of cloud and (*b*) humidity of the air.

The first conclusion from an examination of the amplitudes of the four components of the harmonic resolution of the diurnal variation of temperature is that the relation or ratio of the amplitudes is remarkably constant from station to station and also from month to month. This is easily seen from the following data for the four typical months of January, April, July and November for 28 stations. In the table (Table XLII) the amplitude of the first component is assumed as unit and those of the three remaining co-efficients are expressed as ratios.

TABLE XLII—*Showing ratios of the amplitudes of* U_2, U_3 and U_4 to U_1 *of temperature.*

Station.	January.			April.			July.			November.		
	$\frac{U_2}{U_1}$	$\frac{U_3}{U_1}$	$\frac{U_4}{U_1}$	$\frac{U_2}{U_1}$	$\frac{U_3}{U_1}$	$\frac{U_4}{U_1}$	$\frac{U_2}{U_1}$	$\frac{U_3}{U_1}$	$\frac{U_4}{U_1}$	$\frac{U_2}{U_1}$	$\frac{U_3}{U_1}$	$\frac{U_4}{U_1}$
Lahore	·35	·02	·08	·21	·10	·04	·19	·06	·02	·34	·02	·09
Kurrachee	·32	·08	·07	·34	·08	·07	·33	·04	·06	·33	·07	·07
Roorkee	·30	·05	·05	·18	·10	·06	·16	·10	·02	·29	·05	·07
Agra	·32	·04	·09	·20	·11	·05	·20	·07	·03	·33	·04	·08
Jaipur	·32	·06	·10	·17	·13	·05	·22	·07	·03	·30	·09	·12
Lucknow	·28	·04	·08	·17	·11	·05	·19	·08	·05	·28	·06	·09
Allahabad	·34	·01	·08	·21	·11	·06	·24	·09	·03	·37	·02	·08
Deesa	·26	·06	·08	·20	·08	·06	·18	·01	·02	·25	·10	·10
Patna	·28	·05	·07	·18	·08	·04	·18	·08	·03	·30	·07	·08
Hazaribagh	·29	·07	·09	·19	·14	·05	·27	·12	·04	·28	·10	·10
Dhubri	·29	·03	·04	·21	·07	·03	·15	·09	·03	·30	·02	·04
Goalpara	·31	·07	·04	·26	·03	·05	·25	·03	·01	·29	·07	·05
Sibsagar	·26	·02	·05	·19	·06	·04	·19	·05	·02	·28	·02	·06
Calcutta	·30	·04	·09	·25	·07	·05	·23	·08	·04	·31	·06	·09
Cuttack	·30	·04	·09	·34	·02	·04	·30	·03	·05	·32	·04	·08
Chittagong	·33	·05	·06	·29	·07	·08	·32	·06	·03	·34	·07	·07
Rangoon	·29	·03	·06	·30	·03	·03	·43	·04	·02	·36	·03	·07
Bombay	·33	·04	·07	·28	·08	·08	·39	·02	·05	·32	·04	·07
Jubbulpore	·28	·05	·06	·16	·09	·05	·24	·05	·03	·24	·06	·07
Pachmarhi	·24	·11	·12	·17	·17	·04	·34	·06	·05	·25	·15	·11
Nagpur	·24	·08	·07	·19	·11	·04	·23	·08	·02	·23	·11	·07
Poona	·23	·09	·08	·25	·07	·07	·33	·01	·03	·22	·10	·05
Belgaum	·26	·09	·10	·32	·04	·05	·44	·05	·09	·28	·07	·08
Bellary	·22	·07	·06	·21	·08	·04	·28	·01	·03	·24	·06	·06
Trichinopoly	·22	·09	·06	·23	·06	·05	·26	·03	·03	·29	·05	·07
Trivandrum	·24	·07	·06	·28	·08	·05	·26	·08	·06	·28	·07	·06
Leh	·35	·04	·06	·24	·07	·05	·24	·06	·04	·35	·02	·09
Aden	·29	·04	·10	·27	·10	·09	·15	·19	·06	·30	·03	·11

Similar comparisons are made in the three following tables for air pressure, aqueous vapour pressure and cloud. An examination of the data in these tables shows that no such uniformity obtains in the Besselian resolution of these elements as holds for temperature :—

TABLE XLIII—*Showing ratios of the amplitudes of U_2, U_3 and U_4 to U_1 of air pressure.*

STATION.	JANUARY.			APRIL.			JULY.			NOVEMBER.		
	$\frac{U_2}{U_1}$	$\frac{U_3}{U_1}$	$\frac{U_4}{U_1}$	$\frac{U_2}{U_1}$	$\frac{U_3}{U_1}$	$\frac{U_4}{U_1}$	$\frac{U_2}{U_1}$	$\frac{U_3}{U_1}$	$\frac{U_4}{U_1}$	$\frac{U_2}{U_1}$	$\frac{U_3}{U_1}$	$\frac{U_4}{U_1}$
Lahore	1·80	0·50	0·21	1·08	0·05	0·03	0·65	0·10	0·05	1·39	0·29	0·08
Kurrachee	1·64	0·34	0·13	1·52	0·06	0·01	1·78	0·21	0·06	1·71	0·29	0·06
Roorkee	2·28	0·43	0·26	1·12	0·07	0·02	0·89	0·12	0·02	1·63	0·28	0·13
Agra	1·77	0·33	0·16	0·98	0·08	0·04	1·08	0·15	0·04	1·51	0·22	0·07
Jaipur	1·98	0·49	0·18	1·06	0·06	0·01	1·19	0·14	0·04	1·65	0·34	0·10
Lucknow	1·47	0·18	0·13	0·97	0·02	0·01	1·41	0·10	0·06	1·37	0·25	0·04
Allahabad	1·70	0·34	0·13	1·08	0·04	0·01	1·18	0·15	0·04	1·43	0·28	0·08
Deesa	1·87	0·30	0·15	1·04	0·03	0·01	1·36	0·10	0·07	1·73	0·16	0·09
Patna	1·62	0·24	0·14	0·97	0·07	0·01	1·34	0·14	0·02	1·43	0·14	0·05
Hazaribagh	1·95	0·45	0·16	1·22	0·03	0·04	1·96	0·20	0·05	1·73	0·34	0·15
Dhubri	1·28	0·29	0·07	0·95	0·05	0·02	1·11	0·12	0·02	1·34	0·18	0·04
Goalpara	1·51	0·37	0·11	0·92	0·02	0·04	1·36	0·13	0·08	1·27	0·26	0·08
Sibsagar	1·35	0·24	0·07	1·14	0·08	0·07	0·99	0·07	0·04	1·16	0·17	0·05
Calcutta	1·62	0·32	0·12	1·24	0·06	0·03	1·68	0·13	0·03	1·59	0·26	0·09
Cuttack	1·45	0·18	0·07	1·18	0·06	0·04	1·38	0·08	0·02	1·44	0·20	0·03
Chittagong	1·84	0·38	0·11	1·43	0·10	0·04	1·99	0·20	0·04	1·61	0·25	0·08
Rangoon	1·49	0·26	0·03	0·98	0·03	0·05	1·88	0·12	0·13	1·61	0·30	0·06
Bombay	2·10	0·32	0·17	1·39	0·03	0·01	3·58	0·35	0·07	2·00	0·23	0·10
Jubbulpore	1·56	0·17	0·09	1·09	0·01	0·04	1·50	0·10	0·06	1·44	0·15	0·09
Pachmarhi	3·40	0·63	0·24	1·51	0·08	0·02	2·06	0·20	0·02	2·92	0·40	0·15
Nagpur	1·54	0·22	0·08	0·91	0·03	0·01	1·54	0·14	0·04	1·48	0·21	0·07
Poona	1·53	0·21	0·08	1·33	0·03	0·02	6·14	0·49	0·10	1·28	0·11	0·06
Belgaum	1·96	0·25	0·07	1·69	0·10	0·05	5·47	0·39	0·13	2·21	0·21	0·12
Bellary	1·36	0·16	0·04	1·07	0·02	0·02	1·53	0·06	0·02	1·58	0·15	0·03
Trichinopoly	2·01	0·12	0·06	1·38	0·06	0·05	1·51	0·07	0·04	2·47	0·13	0·09
Trivandrum	2·36	0·20	0·07	2·68	0·07	0·07	3·00	0·08	0·03	3·15	0·21	0·06
Leh	1·03	0·34	0·12	0·61	0·09	0·03	0·39	0·02	0·02	0·61	0·18	0·04
Aden	1·80	0·26	0·08	1·30	0·07	0·06	0·67	0·08	0·07	1·91	0·17	0·10

TABLE XLIV—*Showing ratios of the amplitudes of U_2, U_3 and U_4 to U_1 of aqueous vapour pressure.*

Station.	January.			April.			July.			November.		
	$\frac{U_2}{U_1}$	$\frac{U_3}{U_1}$	$\frac{U_4}{U_1}$	$\frac{U_2}{U_1}$	$\frac{U_3}{U_1}$	$\frac{U_4}{U_1}$	$\frac{U_2}{U_1}$	$\frac{U_3}{U_1}$	$\frac{U_4}{U_1}$	$\frac{U_2}{U_1}$	$\frac{U_3}{U_1}$	$\frac{U_4}{U_1}$
Lahore	0·73	0·69	0·16	1·04	0·08	0·28	0·80	0·18	0·26	1·22	1·10	0·23
Kurrachee	0·19	0·13	0·07	0·21	0·24	0·39	0·62	0·72	0·14	0·14	0·12	0·11
Roorkee	0·84	0·88	0·31	0·80	0·10	0·27	1·01	0·29	0·29	0·73	0·63	0·41
Agra	0·47	0·45	0·13	0·70	0·16	0·25	1·15	0·09	0·12	0·62	0·34	0·16
Jaipur	0·72	0·51	0·12	2·01	0·12	0·64	6·11	0·62	1·19	1·06	0·97	0·17
Lucknow	0·56	0·58	0·14	1·82	0·74	0·59	0·87	0·05	0·32	0·89	0·83	0·20
Allahabad	0·18	0·39	0·14	0·70	0·08	0·15	0·50	0·15	0·18	0·53	0·58	0·28
Deesa	0·61	1·32	0·24	0·31	0·20	0·09	4·79	1·59	0·51	0·51	0·52	0·20
Patna	0·33	0·26	0·08	1·12	0·11	0·31	0·29	0·08	0·05	0·71	0·43	0·09
Hazaribagh	0·77	0·24	0·22	0·30	0·11	0·13	0·63	0·32	0·10	1·02	0·17	0·30
Dhubri	1·44	0·48	0·36	4·05	1·19	1·24	0·33	0·09	0·09	0·90	0·28	0·19
Goalpara	0·99	0·29	0·28	0·53	0·25	0·11	0·20	0·07	0·08	0·72	0·25	0·19
Sibsagar	0·21	0·23	0·06	0·29	0·17	0·09	0·18	0·16	0·03	0·28	0·28	0·10
Calcutta	0·74	0·46	0·13	0·64	0·16	0·08	0·19	0·21	0·09	0·62	0·41	0·17
Cuttack	0·78	0·39	0·01	0·50	0·15	0·06	0·55	0·08	0·24	0·60	0·44	0·02
Chittagong	0·96	0·67	0·40	0·72	0·36	0·18	0·32	0·10	0·06	0·39	0·34	0·19
Rangoon	3·63	1·47	0·36	1·01	0·27	0·24	0·58	0·12	0·08	0·81	0·71	0·02
Jubbulpore	0·46	0·48	0·12	0·83	0·33	0·19	0·44	0·09	0·04	1·10	0·56	0·19
Pachmarhi	0·38	0·14	0·17	0·80	0·75	0·22	0·25	0·03	0	0·43	0·14	0·39
Nagpur	0·79	0·19	0·15	0·53	0·17	0·15	0·69	0·09	0·09	3·20	0·97	0·45
Poona	0·44	0·19	0·13	0·51	0·06	0·09	0·63	0·28	0·22	0·35	0·10	0·05
Belgaum	0·90	0·26	0·24	0·60	0·21	0·04	0·41	0·53	0·17	1·21	0·46	0·17
Bellary	0·43	0·15	0·10	0·49	0·08	0·08	1·86	0·71	0·23	1·38	0·46	0·44
Trichinopoly	1·88	0·15	0·50	0·34	0·02	0·07	0·69	0·13	0·16	0·93	0·32	0·06
Trivandrum	0·15	0·10	0·10	0·10	0·14	0·38	0·65	0·19	0·29	0·35	0·14	0·12
Leh	0·38	0·04	0·05	2·08	0·76	0·95	0·16	0·33	0·10	0·24	0·16	0·21
Aden	1·56	0·35	0·14	0·86	0·33	0·09	0·13	0·19	0·03	0·85	0·22	0·08

TABLE XLV—*Showing the ratios of the amplitudes of U_2, U_3 and U_4 to U_1 of cloud proportion for seven selected stations in India.*

Station.	January.			April.			July.			November.		
	$\frac{U_2}{U_1}$	$\frac{U_3}{U_1}$	$\frac{U_4}{U_1}$	$\frac{U_2}{U_1}$	$\frac{U_3}{U_1}$	$\frac{U_4}{U_1}$	$\frac{U_2}{U_1}$	$\frac{U_3}{U_1}$	$\frac{U_4}{U_1}$	$\frac{U_2}{U_1}$	$\frac{U_3}{U_1}$	$\frac{U_4}{U_1}$
Deesa	·12	·18	·07	·43	·09	·11	·39	1·07	·55	·41	·19	·14
Patna	·41	·22	·23	1·14	·33	·76	·20	·46	·35	1·26	·69	·44
Dhubri	·52	·67	·41	·12	·19	·14	·33	·39	·22	·31	·63	·64
Rangoon	·63	·65	·07	·28	·30	·12	·30	·28	·08	·21	·19	·10
Nagpur	·51	·44	·05	·81	·33	·06	·51	·25	·27	·34	·28	·04
Bellary	·04	·15	·05	·49	·38	·08	·30	·24	·04	·15	·27	·03
Aden	·46	·24	·10	·40	·04	·07	·22	25	·16	·73	·22	·15

The following are important inferences derived from the comparison of the figures of Tables XLII to XLV.

(1) The values of the ratios for aqueous vapour pressure and cloud vary very largely and in the most irregular manner from station to station and from period to period, to such an extent that it would be hardly possible to assign any regular law of variation.

(2) The values of the ratios for temperature are on the other hand remarkably consistent. The following gives mean values of these ratios for four months of the year:—

Ratio.	January.	April.	July.	November.
$\frac{U_2}{U_1}$	·29	·23	·26	·30
$\frac{U_3}{U_1}$	·06	·08	·06	·06
$\frac{U_4}{U_1}$	·07	·05	·04	·08

The following gives corresponding values for each of the four large divisions of the stations:—

	Ratio.	January.	April.	July.	November.
Tropical Coast Stations	$\frac{U_2}{U_1}$	·31	·28	·31	·32
	$\frac{U_3}{U_1}$	·05	·07	·08	·04
	$\frac{U_4}{U_1}$	·07	·06	·05	·08

	Ratio.	January.	April.	July.	November.
Tropical Inland Stations	$\frac{U_2}{U_1}$	·24	·23	·31	·25
	$\frac{U_3}{U_1}$	·09	·09	·04	·09
	$\frac{U_4}{U_1}$	·08	·05	·04	·07
Extra-Tropical Coast and Assam Stations	$\frac{U_2}{U_1}$	·30	·27	·25	·31
	$\frac{U_3}{U_1}$	·05	·06	·05	·05
	$\frac{U_4}{U_1}$	·06	·05	·03	·07
Extra-Tropical Inland Stations	$\frac{U_2}{U_1}$	·31	·19	·21	·30
	$\frac{U_3}{U_1}$	·04	·10	·07	·06
	$\frac{U_4}{U_1}$	·08	·05	·03	·09

The following gives corresponding data for the ratios in the case of air pressure:—

Ratio.	January.	April.	July.	November.
$\frac{U_2}{U_1}$	1·76	1·21	1·81	1·67
$\frac{U_3}{U_1}$	0·30	0·05	0·15	0·23
$\frac{U_4}{U_1}$	0·12	0·03	0·05	0·08

The following gives corresponding values for each of the four large divisions of the stations:—

	Ratio	January	April	July	November.
Tropical Coast Stations	$\frac{U_2}{U_1}$	1·94	1·59	2·28	2·17
	$\frac{U_3}{U_1}$	0·26	0·05	0·16	0·23
	$\frac{U_4}{U_1}$	0·09	0·05	0·08	0·08
Tropical Inland Stations	$\frac{U_2}{U_1}$	1·97	1·32	3·04	1·99
	$\frac{U_3}{U_1}$	0·27	0·05	0·23	0·20
	$\frac{U_4}{U_1}$	0·10	0·03	0·06	0·09

	Ratio.	January.	April.	July.	November.
Extra-Tropical Coast and Assam Stations	$\frac{U_2}{U_1}$	1·53	1·20	1·47	1·46
	$\frac{U_3}{U_1}$	0·30	0·06	0·13	0·23
	$\frac{U_4}{U_1}$	0·10	0·04	0·04	0·06
Extra-Tropical Inland Stations	$\frac{U_2}{U_1}$	1·73	1·02	1·18	1·45
	$\frac{U_3}{U_1}$	0·34	0·05	0·12	0·24
	$\frac{U_4}{U_1}$	0·16	0·02	0·04	0·08

Another important conclusion is that the epochs of the maximum and minimum amplitudes of the four components of temperature agree very closely in time at each station. The following gives data for this comparison:—

TABLE XLVI—*Showing time of occurrence of the epoch of the maximum amplitude of the four components of the harmonic formula representing the diurnal variation of temperature.*

STATION.	First component.	Second component.	Third component.	Fourth component.
Lahore	April	November	May	November.
Kurrachee	November	Ditto	December	Ditto.
Roorkee	Ditto	Ditto	April	October.
Agra	April	Ditto	Ditto	December.
Jaipur	November	December	Ditto	November.
Lucknow	Ditto	Ditto	Ditto	Ditto.
Allahabad	April	Ditto	Ditto	February.
Deesa	November	Ditto	November	December.
Patna	March	Ditto	April	November.
Hazaribagh	April	January	Ditto	February.
Dhubri	March	February	Ditto	Ditto.
Goalpara	February	Ditto	December	March.
Sibsagar	December	December	May	February.
Calcutta	February	January	April	Ditto.
Cuttack	January	April	January	January.

TABLE XLVI—*Showing time of occurrence of the epoch of the maximum amplitude of the four components of the harmonic formula representing the diurnal variation of temperature*—concld.

STATION.	First component.	Second component.	Third component.	Fourth component.
Chittagong	February	February	February	February.
Rangoon	Ditto	Ditto	March	January.
Bombay	Ditto	January	April and May	March.
Jubbulpore	December	December	April	November.
Pachmarhi	January	Ditto	February	January.
Nagpur	March	Ditto	April	February.
Poona	Ditto	February	March	January.
Belgaum	February	April	February	Ditto.
Bellary	Ditto	February	Ditto	Ditto.
Trichinopoly	Ditto	May	March	February.
Leh	September	November	June	September.
Aden	October	October	August	October.

TABLE XLVII—*Showing the time of occurrence of the epoch of the minimum amplitude of the four components of the harmonic formula representing the diurnal variation of temperature.*

STATION.	First component.	Second component.	Third component.	Fourth component.
Lahore	August	July	January	July.
Kurrachee	Ditto	August	September	June.
Roorkee	July	July	Ditto	July.
Agra	August	Ditto	August	Ditto.
Jaipur	July	Ditto	Ditto	Ditto.
Lucknow	August	Ditto	Ditto	August.
Allahabad	July	Ditto	October	July.
Deesa	August	Ditto	July	Ditto.
Patna	Ditto	August	September	Ditto.
Hazaribagh	Ditto	Ditto	Ditto	Ditto.
Dhubri	July	July	Ditto	May.
Goalpara	Ditto	Ditto	Ditto	July.
Sibsagar	Ditto	Ditto	January	Ditto.
Calcutta	August	Ditto	August	Ditto.
Cuttack	Ditto	September	June	June.
Chittagong	Ditto	June	September	July.
Rangoon	Ditto	August	June	Ditto.
Bombay	July	July	July	Ditto.

TABLE XLVII—*Showing the time of occurrence of minimum epoch corresponding to minimum amplitude of temperature*—concld.

Station.	First component.	Second component.	Third component.	Fourth component.
Jubbulpore	July	July	August	August.
Pachmarhi	Do.	August	Ditto	July.
Nagpur	Do.	July	June	Do.
Poona	Do.	Do.	July	Do.
Belgaum	Do.	August	August	August.
Bellary	Do.	June	July	July.
Trichinopoly	June	November	October	Do.
Leh	January	June	December	June.
Aden	Ditto	July	January	May.

It will be sufficient to analyse the data given in the second of the two tables (Tables XLVI and XLVII).

The minimum values of the amplitudes of all the four components occur in the same month (July) at Poona and Bombay.

The minimum values of the amplitudes of the four components occur in the same month, and in either the preceding or succeeding month at eleven stations as shown below:—

Station.	Time of occurrence of the epoch of the minimum amplitudes of the four components representing the diurnal variation of temperature.
Kurrachee	2 in August, 1 in September and 1 in June.
Agra	2 in July and 2 in August.
Jaipur	3 in July and 1 in August.
Lucknow	3 in August and 1 in July.
Deesa	3 in July and 1 in August.
Calcutta	2 in July and 2 in August.
Jubbulpore	Ditto ditto.
Pachmarhi	Ditto ditto.
Nagpur	3 in July and 1 in June.
Belgaum	3 in August and 1 in July.
Bellary	3 in July and 1 in June.

Three of the minimum values occur in the same month, July, at four stations, *viz.*, Roorkee, Allahabad, Goalpara and Sibsagar and the fourth in September, October or January.

The data hence show the very marked tendency for the monthly amplitudes of the four components to increase and decrease together, so that the maxima values of all tend to occur about February and March (*i.e.* at the commencement of the hot weather) and the minima about July or August (in the height of the rains).

Comparison of the Besselian constants for the diurnal variation of pressure and temperature.

A considerable number of inferences of importance follow from this comparison. The most noteworthy are as follows :—

(1) The phases of the second component of the diurnal variation of air pressure and temperature differ almost exactly by 90°. This is shown very clearly by the following data for the phases of that component for the mean day of the year at ten stations :—

Station.	Annual phases of the second component of					
	Pressure.		Temperature		Difference	
	°	′	°	′	°	′
Calcutta	147	50	49	9	98	41
Patna	149	5	60	7	88	58
Allahabad	150	13	56	56	93	17
Lahore	138	18	52	45	85	33
Jaipur	151	30	57	6	94	24
Nagpur	154	44	61	35	93	9
Poona	161	31	67	48	93	33
Bellary	152	17	52	37	99	40
Madras	157	47	57	6	100	41
Rangoon	153	3	59	59	93	4

The physical interpretation of this is that the maximum epoch of the second component of the diurnal variation of the air pressure is simultaneous with the epoch of greatest rate of change of temperature due to the second component, as will be seen by the following comparison for the mean day of the year of eight typical stations .—

Station.	Maximum epoch of the second component of pressure on the mean day of the year.	Epoch of the greatest rate of change of temperature due to second component.	Difference
			Min.
Lahore	10-23 A.M. & P.M.	10-14 A.M. & P.M.	9
Calcutta	10-4 ,,	10-22 ,,	18
Allahabad	10-0 ,,	10-6 ,,	6
Jaipur	9-57 ,,	10 6 ,,	9
Nagpur	9-51 ,,	9-57 ,,	6
Poona	9-37 ,,	9-44 ,,	7
Bellary	9-55 ,,	10-15 ,,	20
Rangoon	9-54 ,,	10-0 ,,	6

The mean of the differences between the two epochs for these stations is only 10 minutes.

(2) A comparison of the amplitudes of the second components of the diurnal variation of temperature and pressure shows that there is no direct and closely marked relation between the two.

The following gives the annual values of the amplitudes of these two elements for the same stations for which data are given in the preceding table:—

Station.	Annual values of amplitude of second component of — Pressure.	Temperature.
Calcutta	″ ·04007	° 1·467
Patna	·03838	1·935
Allahabad	·03584	2·840
Lahore	·02450	2·676
Jaipur	·03311	2·596
Nagpur	·03936	2·081
Bellary	·04214	2·026
Rangoon	·03994	2·079

CHAPTER V.

AQUEOUS VAPOUR PRESSURE.

In the present chapter is given an analysis of the changes of aqueous vapour pressure during the day in India in the different seasons of the year.

It is certain that in India at least during the dry season of the year, the observations of the instruments employed for the determination of the hygrometric conditions of the air are tainted with occasional errors due to the observers not supplying sufficient water to the reservoir of the wet bulb, and in a less degree to their not keeping the instruments clean. The determination of the amount of aqueous vapour present in the air is effected by the employment of a mathematical formula in which the constants have been determined, chiefly from observations in European countries, and although probably correct for the range of variation in these countries by no means give accurate results at certain seasons of the year in India. Cases for instance are of occasional occurrence at very damp stations in the rains, *e.g.*, Akyab, Darjeeling, in which the wet bulb reads slightly higher than the dry bulb. Again, the air is under some exceptional circumstances so dry at the driest stations that the humidity calculated by the formula is a negative quantity (cases of minus 2 for the relative humidity at three or four of the driest stations in India having been actually determined from Regnault's formula modified by August).

Although the observations and data are hence not so accurate as might be desired, they give, so far as can be judged, a fairly approximate and correct view of the diurnal variation of the amount of vapour present in the air.

It has not been thought necessary to translate the data into amounts of vapour in grains per cubic foot, as the vapour pressure is approximately proportional to the actual amount of vapour per unit volume for moderate changes of temperature.

The actual variations of the aqueous vapour pressure on any given day are due to—

(*1st*) What may be termed the normal regular diurnal variations, produced by general actions to be discussed later.

(*2nd*) Large, irregular variations succeeding each other very rapidly and apparently following no law of any kind, but resembling to some extent the changes in the intensity of the air movement as measured by a Dines's air pressure anemometer.

(*3rd*) Changes in progress due to abnormal weather conditions, as, for example, the march of cyclonic storms, the prevalence for some days of excessively hot weather with strong hot winds, etc.

It is only when the data of a longish period are averaged and smoothed, either by free hand or by Bessel's formula, that a tolerably regular law for the diurnal variation of the aqueous vapour pressure is obtained.

It should be premised that the pressure is measured in terms of a column of mercury at temperature 0° C. and constant gravity Lat. 45° (*vide* International Meteorological Tables, pages B 29 to B 32.) If there were no change during the day in the actual

amount of vapour present in unit volume the pressure would vary slightly due to the temperature changes of the combined dry air and vapour. The variations of pressure due to this cause would rarely be more than 2 per cent. of the mean vapour pressure of the day. The amplitude of the change is so small that for most purposes it may be assumed the pressure of the aqueous vapour is independent of the temperature changes and is proportional to the actual amount of vapour present in unit volume which varies largely during the day due to other causes.

There are two features of peculiar interest in the variations of the aqueous vapour pressure which differentiate it from air pressure and temperature.

These are :—

1st—the relative magnitude of the diurnal oscillation, more especially when compared with that of the total air pressure ;

2nd—the magnitude and rapidity of the changes which occur, more especially in the dry season in India, and as it may be termed the variability of the aqueous vapour pressure.

The following gives some examples of the large diurnal range of the aqueous vapour pressure as compared with the total air pressure :—

Station.	Month.	Air Presure.			Aqueous Vapour Pressure.		
		Mean.	Daily Range.	Percentage.	Mean.	Daily Range.	Percentage.
		"	"	"	"	"	"
Allahabad	May	29·319	·126	0·4	·518	·117	23
Belgaum	March	27·373	·135	0·5	·417	·260	62
Calcutta	March	29·854	·131	0·4	·674	·167	25
Cuttack	April	29·693	·141	0·5	·798	·205	26
Deesa	May	29·228	·134	0·5	·546	·209	38
Poona	May	27·948	·118	0·4	·510	·207	41
Trichinopoly	March	29·662	·160	0·5	·662	·145	22

The preceding data indicate that in the typical cases selected the mean amplitude of the diurnal range of the total air pressure is only between $\frac{2}{5}$ and $\frac{1}{2}$ per cent., whereas that of the diurnal range of the aqueous vapour pressure is as much as 20 to 60 per cent. of the mean vapour pressure. It averages on the mean of the year about 10 per cent. for India generally.

The variability of the aqueous vapour pressure during the 24-hour period can only be fully realized by an examination of the hourly observations. It may be measured by the variability for any given period by calculating the mean of the actual changes from

hour to hour irrespective of sign. This is given in the following table for six days in each season at Allahabad and Calcutta :—

Station.	Season	Variability of aqueous vapour pressure.		
		Whole day.	Day, 8 A.M. to 8 P.M.	Night, 8 P.M. to 8 A.M.
		"	"	"
Allahabad	Dry season	·028	·038	·017
	Wet season	·031	·040	·020
Calcutta	Dry season	·032	·041	·027
	Wet season	·024	·032	·017

Similar data are given for the total air pressure—

Station.	Season.	Variability of total air pressure.		
		Whole day.	Day, 8 A.M. to 8 P.M.	Night, 8 P.M. to 8 A.M.
		"	"	"
Allahabad	Dry season	·012	·015	·010
	Wet season	·013	·015	·011
Calcutta	Dry season	·016	·018	·013
	Wet season	·015	·017	·012

The data show that the variability of the aqueous vapour pressure is generally more than twice as great as that of the total air pressure, although its actual value is from a thirtieth part in the wet season to a seventieth part on the average in the dry season of the air pressure.

This feature is however more strikingly shown by an examination of the actual data of hourly observations. The curves of aqueous vapour pressure for the day hours of the solar eclipse, January 22nd, 1898, given in the Indian Meteorological Memoirs, Vol. XI Part II, Plates XXV to XXIX, illustrate it very clearly. The weather on that day was remarkably fine and free from all disturbance. Yet, as will be seen by a reference to the curves in the Plates XXV to XXIX of that volume, the changes were very large and irregular, in fact to such an extent, that it is hardly apparent from them what the mean or normal changes in such weather would be.

In order to illustrate this feature further, the hourly values of the aqueous vapour pressure for the following stations and dates, *viz.*,—

Allahabad	May 28th, 1885,
Lahore	April 28th, 1886,
Jaipur	March 7th, 1890,
and Roorkee	April 8th, 1878

are given below :—

Hour.	Allahabad. May 28th, 1885.	Lahore. April 28th, 1886.	Jaipur. March 7th, 1890.	Roorkee. April 8th, 1878.
	"	"	"	"
Initial midnight	·393	·417	·270	·317
1	·379	·430	·291	·316
2	·394	·444	·319	·318
3	·498	·440	·326	·327
4	·504	·427	·336	·311
5	·494	·387	·327	·308
6	·504	·471	·338	·309
7	·492	·522	·350	·282
8	·408	·492	·383	·356
9	·338	·578	·343	·289
10	·316	·584	·363	·359
11	·339	·579	·357	·258
Noon	·287	·566	·322	·296
13	·295	·535	·282	·285
14	·320	·666	·278	·245
15	·320	·605	·279	·285
16	·292	·598	·311	·224
17	·405	·767	·273	·250
18	·402	·727	·378	·281
19	·390	·520	·342	·303
20	·436	·517	·320	·269
21	·436	·513	·306	·293
22	·406	·507	·318	·266
23	·421	·508	·312	·255
Final midnight	·401	·484	·301	·286

The data of the preceding table illustrate very clearly the large and rapid irregular changes of aqueous pressure in the interior of India.

The law of variation differs considerably at different seasons and in different parts of India. Hence in the following discussion similar stations are grouped together and the type of variation for these stations is stated, examined and discussed.

Explanations more or less imperfect are given in meteorological treatises of some of the conditions determining the variation of this element of meteorological observations. Much attention has been directed to evaporation from water surface and also to a less extent to the diffusion of aqueous vapour through the air.

Evaporation during certain seasons of the year is undoubtedly a potent factor in modifying or altering the amount of aqueous vapour present in the air, more especially in

The following gives a summary of the preceding remarks :—

(*a*) During the prevalence of land and sea breezes in the coast districts of India very large and sudden changes in the amount of aqueous vapour pressure in the air may occur, more especially during the periods of the transition from the land to the sea breezes, and *vice versâ*.

(*b*) These changes are largest at some distance from the coast, probably from 40 to 100 miles, and are most pronounced at Calcutta, Cuttack, Belgaum and Poona of the stations for which data are available.

(*c*) Similar changes occur at the coast stations, *e.g.*, Bombay, Chittagong, etc., but are by no means so large as at Calcutta, Cuttack, Poona and Belgaum.

(*d*) The alternate action exercises little or no effect in the interior except by the cumulative process explained briefly above.

Similar changes also occur whenever there is a shift of wind from a land to a sea direction, whether the shift be temporary due to temporary meteorological actions or to seasonal changes. As examples may be given the shift of wind from northerly to southerly directions in Bengal during the passage of cold weather storms across North-Eastern India and the seasonal change in Northern India from the normal dry westerly winds of the hot weather to the easterly winds of the south-west monsoon period.

It is not, however, necessary to consider the latter in dealing with the diurnal variation of the aqueous vapour pressure.

The largest changes of an oscillatory character due to this action evidently occur in the coast areas during the prevalence of land and sea breezes. A similar effect on a smaller scale produced by any action will give a larger movement into the interior from the sea during the day than during the night. This action occurs for example in the hot weather and in the rainy season in India. The interior of India, more especially the drier districts of North-Western India and of the Deccan and Southern India, are heated up considerably during the day, and this invariably gives rise to increased air movement and hence in both seasons to an increasing indraught during the day hours, reaching its maximum about 3 P.M. or 4 P.M. In the hot weather the indraught is local, chiefly occurring in the coast districts. In the south-west monsoon period it is general and as marked in the interior as in the coast districts. This action of an oscillatory character, *viz.*, increased movement by day and decreased movement by night, tends to increase the aqueous vapour pressure during the day hours and decrease it during the night hours, and hence to give an [illegible] in the hours period in the diurnal variation of the aque[illegible] oscillatory variation of 24 [illegible]ous vapour pressure.

(5). *The action of large mountain* [illegible] *or plateaus*, by the transfer of masses of air from higher to lower levels, or *vice versâ*. This occurs under various conditions in Northern India. For example [illegible], after the weather clears in the rear of a severe cold weather storm in Northern India, very dry westerly winds set in, producing a very large and rapid decrease of humidity and aqueous vapour pressure. This dry current is apparently chiefly fed from the plateaus and mountain areas to the west of the Indus and spreads eastwards over Northern India. Numerous examples of this action will be found in the Memoir on "Cold Weather Storms in Northern India." Observations have been recently obtained establishing that the winds down the Khyber, Bolan and other passes are at such times very vigorous, sometimes, I am informed, strong enough to blow down tents.

Again there is in the cold and hot weather a well defined alternating motion between

the hills and plains in North-Western India. In the day hours southerly winds blow across the hills from the plains; whilst in the night the air movement is almost as strong, but in the opposite direction. There are return currents in the upper atmosphere from the higher mountains to the plains in the day and *vice versâ* in the night hours, as is frequently shown by cloud observations at Simla and other hill stations. It is very probable that the upper and drier current in the day time is partially fed from Thibet, and hence introduces air of a different hygrometric character which descending over Northern India mixes with the lower air and hence contributes to diminish its humidity. This question has been only partially worked out, but it is probable that it contributes to a considerable extent in modifying the diurnal humidity conditions over Northern India. If this action be a *vera causa*, it is evident that it will tend to give decreasing aqueous vapour tension in the day hours over the plains of Northern India, as it is during that period that the descending dry air from the upper levels chiefly affects the air in the plains of Upper India. The effect during the night hours will apparently be small and negligible in amount. The action will hence tend to give a variation during the day hours having its maximum probably about the hottest time of the day.

(6) and (7). The effects of these actions, *viz* expansion or contraction and varying temperature, are so small that they are generally neglected.

Summary.—These actions, so far as they modify the quantity of vapour present in the lowest air stratum and contribute towards the diurnal variation, will produce changes of the period and character indicated below:—

(1) Diffusion diminishes the aqueous vapour pressure in the lowest strata by amounts which are greatest in the day hours when diffusion is slightly more rapid than in the night hours. This action hence gives rise to a variation of aqueous vapour pressure of 24 hours period, the minimum about 2 P.M. and the maximum during the night hours.

(2) Evaporation produces increase of vapour in the lowest stratum, greatest in the day hours when evaporation is most rapid. The rate of evaporation depends upon a variety of actions. It varies:—

(*a*) Inversely as the relative humidity of the air.

(*b*) Directly as the rate of the air movement over the water or other surface at which evaporation is occurring.

(*c*) Directly as the intensity of the solar radiation and hence inversely as the [illegible] amount of cloud, dust, etc., present in the air.

These are all recurring [illegible] actions of 24-hour period, the maximum intensity of which is about 2 P.M. Evapora[illegible] will hence give an oscillatory variation of aqueous vapour pressure of 24-hour [illegible] period, the maximum of which will be about 2 or 3 P.M. and the minimum in the early morning.

(3) Convective movements with the associated lower horizontal air movements give rise to a day oscillation varying very considerably in period and amplitude. They cause a decrease of vapour pressure, increasing in amount from 9 or 10 A.M. to 3 or 4 P.M. followed by an increase terminating about 7 P.M. The diurnal period of this action in India is on the average of the year about 10 hours. The amplitude varies very greatly with the season, and is a maximum in the Peninsula in March or April and in the interior of Northern India in May.

(4) Land and sea breezes give rise to the largest variations of aqueous vapour pressure. During the prevalence of the land breeze the amount of aqueous vapour is reduced below the mean of the day, the reduction being usually greatest shortly before the transition from the land to the sea breezes. Similarly during the prevalence of the sea breeze the aqueous vapour pressure rises above the mean, reaching its maximum at the coast stations from 2 P.M. to 4 P.M. when they are strongest. The variation in the aqueous vapour pressure due to this action is hence of 24-hour period, the maximum and the minimum occurring at different hours depending upon the distances of the stations affected from the *sea*.

(5) The up and down movements between the mountains of Northern India and adjacent plains give rise to large and irregular changes which probably contribute to reduce the aqueous vapour pressure on the mean in the day hours. This movement is alternating, consisting of a down movement from the hills to the plains in the night hours and up movement from the plains to the hills in the day hours. There is an alternating inverse movement in the upper strata. The effect of the down movement in the night hours may tend to decrease the aqueous vapour slightly at and near the foot of the hills, whilst that of the upper movement in the day hours may tend to give considerable irregularity in the day hours.

The diurnal variation of aqueous vapour pressure in different seasons is due chiefly to the combination of these periodic actions in varying proportions.

The combination of the first and second processes gives under normal conditions an oscillation of 24-hour period.

The combination of the first, second and third processes gives rise to a double oscillation, *viz.*, a small to moderate oscillation in the early morning followed by a considerably larger oscillation during the day and evening hours, the relative importance of the two depending upon a variety of causes.

Land and sea breezes are only important in the coast districts where the convective movements are small. Hence the effects of the land and sea breezes are usually combined with (1) and (2) (and not with 3). The action of the land breeze will tend to increase the early minimum due to (1) and (2) and to emphasize the afternoon maximum considerably to largely. Hence the combination of these, *viz.*, (1), (2) and (4), will give a 24-hourly oscillatory change, the amplitude of which will be large and the day maximum will occur somewhat irregularly, depending upon local and topographical conditions which modify very considerably the intensity and period of the sea breeze.

The effect of the interchange of air between the mountains and plains of Northern India, will probably tend to give on the average a slight decrease of aqueous vapour pressure during the day hours when the upper return current from the snow is descending over the plains. It is very doubtful whether the descending current in the night hours will give any increase or decrease of aqueous vapour in the lowest air stratum over the Gangetic Plain. Hence the effect of this will be to add slightly to the results of the convective movement in the plains of Northern India, and hence the combination of (1), (2), (3) and (5) will produce a double oscillation similar to that of (1), (2) and (3).

Davis states in his Elementary Meteorology (page 152): "The average diurnal variations of the amount of vapour in the air are small." This does not apply to India where the diurnal variation at many stations is occasionally not only large relatively to the mean amount, but is also large absolutely. For example, the amplitude of the diurnal variation of aqueous vapour at Belgaum, Poona and other stations in the hot weather months is nearly twice as large as that of the total air pressure.

Types of the diurnal variation of aqueous vapour pressure.—Angot and Von Bebber recognise two types of diurnal variation of aqueous vapour pressure, the first having a a single maximum and minimum and the second two maxima and minima.

The preceding discussion suggests that in India the diurnal variation of aqueous vapour pressure at different localities and for different seasons may be arranged in four types. This conclusion is fully verified by an examination of the actual curves given in the memoirs.

The simplest type is that in which the variation consists of a single oscillation, the minimum in the early morning at about 4 A.M. and the maximum in the afternoon usually from 4 P.M. to 6 P.M. This type is chiefly exhibited at coast stations, *e.g.*, Bombay, Kurrachee and Aden. This may be designated for convenience as type A.

In the remaining types (designated as types B, C and D) the variation consists of a double oscillation *e.g.*, an early morning oscillation and a day oscillation. The first type of this form, (type B) is characterized by two oscillations of approximately equal amplitude In type C the amplitude of the early morning oscillation is larger than that of the day oscillation, and in type D the amplitude of the day oscillation is large and that of the early morning oscillation is small and in some cases almost evanescent. The following sums up the above:—

Type A.—Single or 24-hourly oscillation, the amplitude of which differs considerably with seasons and locality.

Type B.—Double oscillation of approximately equal amplitudes.

Type C.—Double oscillation, the amplitude of early morning being markedly larger than that of the day oscillation.

Type D.—Double oscillation, the amplitude of the day oscillation being large and that of the early morning oscillation small.

Annual variation.—The annual variation of the amount of aqueous vapour present in the air is very pronounced in India. Curves representing the annual variation for fifteen representative stations in India are given in Plate XXIII. The variation is determined by the alternating influence of the dry and wet seasons or monsoons. In the dry season land winds obtain, and the amount of vapour is hence small over the whole of the interior. A rapid increase of the amount of aqueous vapour present in the air accompanies the setting in of the wet or south-west monsoon and the air over a large part of the country is more or less nearly saturated so long as that monsoon continues in full intensity.

The curves show very clearly the influence of the opposite conditions of the two periods, the dry and wet seasons in India. They also indicate that the period of the full influence of the south-west monsoon decreases considerably on proceeding from the coast districts to the Punjab. The curves representing the annual variation of aqueous vapour in Plate XXIII indicate that the minimum values occur in January or February.

The aqueous vapour pressure decreases with elevation slightly more rapidly in percentage amount than the total air pressure. The rate of decrease is least in the rainy season and greatest in the height of the dry season when there is little or no indraught across the coast districts.

The following gives a few examples:—

Station.	Elevation.	Vapour pressure.			Air pressure.		
		January.	May.	July.	January.	May.	July.
	Feet.	"	"	"	Inches.	Inches.	Inches.
Lahore	702	·27	·44	·85	29·33	29·91	29·77
Simla	7,224	·15	·28	·53	23·10	23·06	22·97
Leh	11,503	·07	·13	·26	19·63	19·69	19·60
Deesa	466	·25	·57	·83	29·54	29·23	29·12
Mount Abu	3,945	·21	·35	·64	26·12	25·96	25·81
Nagpur	1,025	·36	·45	·81	28·96	28·63	28·56
Pachmarhi	3,528	·28	·35	·67	26·52	26·33	26·20

The preceding remarks give the most important points in the seasonal distribution of aqueous vapour in India. The most noteworthy features are as follows:—

(1) The horizontal seasonal changes of vapour pressure and air pressure are roughly proportional at both hills and plains stations.

(2) The vertical changes of vapour pressure are more rapid than those of air pressure.

(3) The changes from the dry monsoon to the south-west monsoon are relatively greater in the interior than in the coast districts and at moderate elevations than at sea level.

Diurnal variation.—We now proceed to examine the more important features of the diurnal variation of aqueous vapour pressure in India during different seasons of the year plotted as curves in Plates XXV to XXX. Stations having similar laws of variation are grouped together and arranged according to the four types (A, B, C and D), described in page 125. The data for these groups are plotted in Plate XXIV.

The cold weather period. (First half of the dry monsoon).—*Data.*—The aqueous vapour present in the air is usually a minimum over the whole of India. In Northern and Central India winds of land origin prevail (from westerly and northerly directions), and hence the air is very dry. In the Peninsula winds are from north-east to east and are the continuation of the gentle air movement from north-east over the Bay. The amount of aqueous vapour is hence larger in the Peninsula than in Northern India and increases southwards and is largest in Southern India. Northerly land winds prevail in Burma ... in Northern India. Land and sea breezes alternate regularly on the west coast ... Peninsula and give rise to a largish diurnal range of aqueous vapour pressure. ... Bengal and Arakan Coasts the wind shifts to some extent during the day, but

as a rule, does not affect the aqueous vapour pressure to any considerable extent. The only disturbances during this period are cold weather storms. These storms modify for short periods the humidity conditions. The air is always damper in the advancing semi-circle of these storms, due in part to shift of winds and in part to rainfall. It is, on the other hand, generally very dry in the rear of the storm where north-westerly winds bring in large masses of air descending from the Baluchistan and Afghanistan plateaus :—

The following table gives data of mean vapour pressure of the period for the larger political divisions of India :—

TABLE LI.

AREA.	AVERAGE AQUEOUS VAPOUR PRESSURE IN		
	January.	February.	Period, January and February.
	"	"	"
Punjab	·262	·273	·268
Sind	·290	·320	·305
Rajputana	·267	·251	·259
North-Western Provinces and Oudh	·299	·298	·299
Bihar	·380	·368	·374
Central India	·289	·270	·280
Chota Nagpur	·268	·253	·261
Bengal	·445	·479	·462
Central Provinces	·332	·315	·325
Berar	·320	·285	·303
Deccan	·481	·494	·488
Burma	·584	·612	·598
South India	·491	·497	·494
Hill stations Kashmir	·113	·116	·115
Hill stations Punjab and North Western Provinces Himalayas.	·159	·167	·163
Hill stations Sikkim Himalayas	·226	·230	·228

Diurnal variation, type A.—The diurnal variation at the stations on or near the sea coast, more especially Kurrachee, Bombay and Trivandrum, conforms to the first type A.

The following table gives data of the hourly variations of the mean aqueous vapour

pressure from the mean of day. The curve of diurnal variation representing this type is plotted in figure 1, Plate XXIV :—

TABLE LII.

Hour.	Variation from mean of day.	Hour.	Variation from mean of day.
	″		″
Midnight	+·0096	Noon . . .	−·0202
1	+·0038	13	−·0059
2	−·0038	14	+·0100
3	−·0148	15	+·0219
4	−·0266	16	+·0295
5	−·0369	17	+·0340
6	−·0423	18	+·0396
7	−·0404	19	+·0439
8	−·0342	20	+·0438
9	−·0317	21	+·0383
10	−·0303	22	+·0270
11	−·0264	23	+·0157

The following gives data of the maximum and minimum values of the variation for each of these stations and for the group of stations :—

Station.	Morning oscillation.		Evening oscillation.		Amplitude.
	Minimum.		Maximum.		
	Epoch.	Variation.	Epoch.	Variation.	
		″		″	″
Kurrachee	6 A.M.	−·0375	8 P.M.	+·0456	·0831
Bombay	7 „	−·0485	4 „	+·0525	·1010
Trivandrum	6 „	−·0424	8 „	+·0508	·0932
Mean of group . .	6 A.M.	−·0423	7 P.M.	+·0439	·0862

The diurnal variation of aqueous vapour pressure at these stations hence consists of a single oscillation, the minimum epoch of which is at about 6 A.M. and the maximum at 7 P.M. The amplitude differs slightly in amount at these stations and averages ·086,″ the mean pressure for the stations being ·551″. The variation at these stations is due chiefly to the alternating action of the land and sea breezes which obtain at these stations during this period.

Diurnal variation, type B.—The diurnal variation belongs to the second type (B) at the great majority of the interior stations in Northern and Central India. The amplitude

of the variation is not large and the variation consists of a small night and small to moderate day oscillation. The following stations belong to this type:—

Lahore.	Rangoon.
Chittagong.	Trichinopoly.
Jubbulpore.	Aden.
Lucknow.	Jaipur.
Agra.	Roorkee.
Allahabad.	Dhubri.
Hazaribagh.	Deesa.

The following table gives the hourly variations of the aqueous vapour pressure from the mean of the day on the average of all those stations (excluding Aden). The curve representing the diurnal variation at these stations is plotted in figure 2, Plate XXIV:—

TABLE LIII.

HOUR.	Variation from mean of day.	HOUR.	Variation from mean of day.
Midnight	+·0041	Noon	+·0005
1	+·0009	13	−·0105
2	−·0025	14	−·0174
3	−·0074	15	−·0172
4	−·0130	16	−·0102
5	−·0174	17	+·0007
6	−·0173	18	+·0112
7	−·0115	19	+·0181
8	−·0015	20	+·0201
9	+·0084	21	+·0179
10	+·0130	22	+·0132
11	+·0099	23	+·0082

The curves of Roorkee, Rangoon and Trichinopoly for January and February (*vide* Plates XXV, XXVI and XXVII) may be cited as representative curves of this type of variation in different parts of India. The following gives the epochs of the maxima and

minima values, the variations of the maxima and minima from the mean and the amplitude of the mean diurnal variation for each station of this group:—

Station.	Morning oscillation.				Afternoon or evening oscillation				Amplitude or diurnal range.
	Minimum.		Maximum.		Minimum.		Maximum.		
	Epoch.	Variation.	Epoch.	Variation	Epoch	Variation.	Epoch	Variation	
		"		"		"		"	"
Lahore	6 A.M.	—·0219	10 A.M.	+·0158	3 P.M.	—·0144	7 P.M.	+·0253	·0472
Roorkee	6 "	—·0212	11 "	+·0227	3 "	—·0147	7 "	+·0168	·0439
Jaipur	5 "	—·0175	11 "	+·0060	2 "	—·0102	7 "	+·0285	·0460
Agra	7 "	—·0146	11 "	—·0026	2 "	—·0217	7 "	+·0296	·0513
Lucknow	6 "	—·0285	10 "	+·0186	2 "	—·0081	7 "	+·0239	·0524
Allahabad	6 "	—·0231	11 "	+·0059	2 "	—·0115	6 "	+·0354	·0585
Hazaribagh	5 "	+·0020	8 "	+·0100	3 "	—·0240	8·30 "	+·0145	·0385
Jubbulpore	5 "	—·0232	11 "	+·0052	2 "	—·0087	7 "	+·0283	·0515
Dhubri	6 "	—·0214	11 "	+·0218	3 "	—·0159	10 "	+·0194	·0432
Chittagong	6 "	—·0351	10 "	+·0245	2 "	—·0147	8 "	+·0221	·0596
Trichinopoly	5 "	—·0014	9 "	+·0246	5 "	—·0369	11 "	+·0260	·0629
Deesa	5 "	—·0080	11 "	+·0110	3 "	—·0080	7 "	+·0090	·0190
Rangoon	5 "	—·0207	9 "	+·0347	2 "	—·0620	9 "	+·0500	·1120
Aden	5 "	—·0026	9 "	+·0135	4 "	—·0268	9 "	+·0152	·0420
Mean of group	5 A.M.	—·0174	10 A.M.	+·0130	2 P.M.	—·0174	8 P.M.	+·0201	·0375

The double oscillation at the stations in the interior of Northern India is due to the superposition of a slight to moderate convective action (of about ten hours period) on the actions of evaporation and diffusion (of twenty-four hours period).

The double oscillation at the coast stations of Chittagong and Aden is probably due to a somewhat different combination of actions.

Diurnal variation, type C.—The diurnal variation conforms to the type C, a double oscillation in which the second or afternoon oscillation is very feeble, in the case of the stations of Sibsagar, Goalpara, Patna, Bellary and Nagpur.

The following table gives the mean variation of the aqueous vapour pressure from the mean of day for these stations. The curve of diurnal variation of this type is plotted in figure 3, Plate XXIV:—

TABLE LIV.

Hour.	Variation from mean of day.	Hour.	Variation from mean of day.
	"		"
Midnight	—·0082	Noon	+·0233
1	—·0107	13	+·0155
2	—·0132	14	+·0089
3	—·0164	15	+·0057
4	—·0202	16	+·0047
5	—·0244	17	+·0044
6	—·0236	18	+·0037
7	—·0155	19	+·0030
8	—·0011	20	+·0021
9	+·0145	21	+·0011
10	+·0255	22	—·0011
11	+·0278	23	—·0017

The representative curve shows that the variation consists of a large morning oscillation and a very small afternoon oscillation. The aqueous vapour pressure at these stations has its absolute minimum value at about 5 A.M., A rapid increase occurs during the next four hours followed by a moderate fall, 11 A.M. to 3 P.M. and thence by a slow fall during the remainder of the 24-hour period. The following table gives comparative data:—

STATION.	MORNING OSCILLATION.				AFTERNOON OR EVENING OSCILLATION.				AMPLITUDE.
	MINIMUM.		MAXIMUM.		MINIMUM.		MAXIMUM.		
	Epoch.	Variation.	Epoch.	Variation.	Epoch.	Variation.	Epoch.	Variation.	
		"		"		"		"	"
Patna	5-30 A.M.	—·0365	11 A.M.	+·0170	2 P.M.	+·0040	6-30 P.M.	+·0215	·0580
Bellary			10 "	+·0490	6 "	—·0260			·0750
Nagpur	5-30 A.M.	—·0225	0-30 P.M.	+·0175	5-30 "	+·0045	8 "	+·0070	·0400
Sibsagar	6 "	—·0527	Noon.	+·0343	3 "	+·0209	6 "	+·0296	·0870
Goalpara	6 "	—·0133	11 A.M.	+·0332	7 "	—·0148	11 "	—·0019	·0480
Mean	5 A.M.	—·0244	11 A.M.	+·0278					·0522

At these stations the 24-hour variation due to evaporation is of large amplitude whilst the variation due to convective action is small.

Diurnal variation, type D.—The diurnal variation of aqueous vapour pressure of the stations of Poona, Belgaum, Cuttack and Calcutta (all of which are at a moderate distance from the sea and within the limits of the sea and land breezes but near the outside verge) and Leh and Pachmarhi belongs to the fourth type D, in which the day oscillation is large and the early morning oscillation is of small amplitude and almost evanescent.

The following table gives mean hourly variation of the aqueous vapour pressure from the mean of day deduced from the data for these six stations. The curve representing the diurnal variation of this type is plotted in figure 4, Plate XXIV:—

TABLE LV.

HOUR.	Variation from mean of day.	HOUR.	Variation from mean of day.
	"		"
Midnight.	+·0183	Noon.	—·0237
1	+·0158	13	—·0329
2	+·0129	14	—·0388
3	+·0087	15	—·0395
4	+·0042	16	—·0330
5	+·0016	17	—·0190
6	+·0022	18	—·0006
7	+·0047	19	+·0168
8	+·0060	20	+·0280
9	+·0034	21	+·0307
10	—·0034	22	+·0274
11	—·0133	23	+·0223

The important feature of this type is a large day oscillation, the minimum of which is at about 3 P.M., and the maximum at about 9 P.M. The early morning oscillation is almost evanescent. It gives a very slight increase of pressure from 5 A.M. to 8 A.M.

The following table gives the epochs of the maxima and minima at the six stations, the diurnal variation at which is of the type D :—

Station.	Morning oscillation.				Day oscillation.				Amplitude.
	Minimum		Maximum		Minimum.		Maximum.		
	Epoch.	Variation	Epoch.	Variation	Epoch	Variation	Epoch.	Variation	
		"		"		"		"	"
Belgaum . . .	5 A.M.	—·0002	7 A.M.	+·0057	2 P.M.	—·0708	8 P.M.	+·0730	·1438
Poona	5 "	+·0202	8 "	+·0228	2 "	—·0195	10 "	+·0310	·0805
Cuttack	6 "	+·0002	9 "	+·0088	3 "	—·0752	9 "	+·0442	·1194
Calcutta	6 "	—·0034	8 "	+·0001	3 "	—·0540	8 "	+·0410	·0950
Leh	6 "	—·0161					2 "	+·0207	·0368
Pachmarhi . . .	1-30 "	—·0065	8 "	+·0140	4 "	—·0180	9 "	+·0030	·0320
Mean . . .	5 A.M.	+·0016	8 A.M.	+·0060	3 P.M.	—·0395	9 P.M.	+·0307	·0702

The diurnal variation at the four plains stations is the resultant effect of the actions of evaporation and diffusion, of convective air movement, and of the alternating air movement of the land and sea breezes. The last is probably the most important factor. The day maximum occurs about three hours later at these stations than at the corresponding coast stations.

The hot weather period. (Second half of the dry monsoon).—The conditions during this period resemble those of the preceding period to a considerable extent. Land winds prevail over the greater part of the interior from mean directions differing little from those of the cold weather. The increasing temperature, however, not only increases the horizontal air movement, but also the convective movement and the interchange between the plains and hills in Northern India. Local sea winds set in across the Bengal and North Bombay coasts in March. They increase in strength and extend further into the interior with the increasing intensity of the thermal conditions in April and May. Hence in the interior of India the chief effect of these hot weather conditions and actions is to increase the amplitude of the diurnal changes of the aqueous vapour pressure without modifying appreciably the general form of the representative curves. The law of variation is, on the other hand, modified considerably at stations which come under the influence of the local sea winds of the period.

The following table gives mean data for different provinces or areas:—

TABLE LVI

AREA.	Normal mean aqueous vapour pressure in			
	March.	April.	May.	Period March to May.
	"	"	"	
Punjab	·359	·421	·488	·423
Sind	·446	·548	·669	·554
Rajputana	·315	·363	·510	·396
North-Western Provinces and Oudh	·337	·345	·474	·385
Bihar	·419	·522	·729	·557
Central India	·299	·308	·395	·334
Chota Nagpur	·284	·303	·476	·354
Bengal	·621	·758	·858	·746
Central Provinces	·326	·352	·440	·373
Berar	·292	·301	·417	·337
Deccan	·567	·646	·698	·637
Burma	·721	·826	·887	·811
South India	·562	·654	·698	·638
Hill stations Kashmir	·167	·219	·280	·222
Hill stations Punjab and North-Western Provinces Himalayas	·200	·235	·288	·241
Hill stations Sikkim Himalayas	·279	·350	·452	·360

Diurnal variation, type A.—The first group in which the diurnal variation of aqueous vapour pressure during this period is of the type A, comprises the stations of Kurrachee, Bombay and Trivandrum.

The following table gives mean hourly variation data for this group of stations. The curve representing the diurnal variation at these stations is plotted in Fig. 5, Plate XXIV :—

TABLE LVII.

Hour.	Variation from mean of day.	Hour.	Variation from mean of day.
	"		"
Midnight	+·0086	Noon	—·0111
1	+·0051	13	—·0010
2	—·0007	14	+·0032
3	—·0083	15	+·0095
4	—·0162	16	+·0113
5	—·0202	17	+·0126
6	—·0200	18	+·0155
7	—·0157	19	+·0197
8	—·0150	20	+·0226
9	—·0189	21	+·0218
10	—·0225	22	+·0176
11	—·0180	23	+·0129

The variation consists of a single oscillation, the maximum of which is at 8 P.M. and the minimum at 5 A.M. or 10 A.M. There is a very slight increase from 5 A.M. to 8 A.M. The variation at these stations is chiefly due to the varying strength of the local in-draught from the sea to the land.

Diurnal variation, type B.—The diurnal variation of aqueous vapour pressure belongs to type B (double oscillation of nearly equal amplitudes) at the following group of stations:—

(1) Lahore,
(2) Roorkee,
(3) Agra,
(4) Lucknow,
(5) Allahabad,
(6) Patna,
(7) Jaipur,
(8) Dhubri,
(9) Nagpur,
(10) Jubbulpore,
(11) Aden,
(12) Pachmarhi,
and also at
(13) Leh

The variation is very slight at the two hill stations.

The curve representing the diurnal variation of aqueous vapour pressure from the mean of the day on the average of the eleven plains stations in the preceding list is plotted in Fig. 6, Plate XXIV from the data of the following table:—

TABLE LVIII.

Hour.	Variation from mean of day.	Hour.	Variation from mean of day.
	"		"
Midnight	+·0066	Noon	—·0060
1	+·0050	13	—·0172
2	+·0022	14	—·0275
3	—·0014	15	—·0343
4	—·0027	16	—·0342
5	+·0010	17	—·0258
6	+·0096	18	—·0116
7	+·0191	19	+·0028
8	+·0245	20	+·0119
9	+·0231	21	+·0139
10	+·0158	22	+·0115
11	+·0053	23	+·0084

The following gives data of the epochs and amplitudes of the double oscillation at each of these stations:—

TABLE LIX.

Station.	Morning oscillation.				Afternoon and Evening oscillation.				Amplitude.
	Minimum.		Maximum.		Minimum.		Maximum.		
	Epoch.	Variation.	Epoch.	Variation.	Epoch.	Variation.	Epoch.	Variation.	
		"		"		"		"	"
Allahabad	Mid.	+·0063	7 A.M.	+·0372	3 P.M.	—·0499	9 P.M.	+·0117	·0871
Agra	4 A.M.	+·0028	7 „	+·0159	3 „	—·0437	9 „	+·0282	·0719
Lucknow	4 „	—·0162	9 „	+·0310	4 „	—·0204	9 „	+·c059	·0514
Lahore	4 „	—·0060	8 „	+·0262	3 „	—·0521	8 „	+·0374	·0895
Patna	4 „	—·0128	9 „	+·0325	5 „	—·0272	10 „	+·0034	·0597
Roorkee	3 „	+·0004	8 „	+·0326	3 „	—·0399	9 „	+·0089	·0725
Jaipur	3 „	—·0032	8 „	+·0383	4 „	—·0368	8 „	+·0100	·0751
Nagpur	4 „	—·0025	9 „	+·0305	5 „	—·0240	1 A.M.	+·0025	·0545
Dhubri	4 „	—·0184	11 „	+·0160	4 „	—·0192	11 P.M.	+·0205	·0397
Jubbulpore	5 „	+·0045	8 „	+·0132	3 „	—·0363	9 „	+·0230	·0593
Aden	4 „	+·0062	9 „	+·0241	4 „	—·0498	10 „	+·0189	·0739
Pachmarhi	1·30 „	—·0065	8 „	+·0140	4 „	—·0180	9 „	+·0030	·0320
Leh	4·30 „	—·0065	0·30 P.M.	+·0055	4 „	—·0050	10 „	+·0030	·0120
Mean	4 A.M.	—·0028	8 A.M.	+·0221	4 P.M.	—·0307	9 P.M.	+·0122	·0528
Mean (excluding Aden and Pachmarhi).	4 „	—·0027	8 „	+·0245	3·30 „	—·0343	9 „	+·0139	·0588

The data of the preceding two tables indicate that the variation consists of two oscillations, a morning and an afternoon oscillation, the former generally considerably feebler than the latter. The minimum of the morning oscillation is at 4 A.M. on the average of all stations and the maximum (more variable) at about 8 A.M. The minimum of the afternoon oscillation is at 3·30 P.M. on the average of the plains stations and the maximum at 9 P.M.

The chief feature of the diurnal variation at these stations during this period is the large afternoon variation, and more especially the large minimum at 3 P.M. It is evidently an effect of the vigorous convective movement of the period, and a reference to the monthly curves of aqueous vapour pressure given in the Indian Meteorological Memoirs, vols. V and IX, will show that the amplitude of this afternoon variation increases *pari pasu* during the season with the increasing intensity of the thermal conditions and of convective action.

Diurnal variation, type C.—The diurnal variation of vapour pressure is of type C. (a double oscillation, the morning oscillation being of large amplitude and the afternoon small and almost evanescent) at Sibsagar, Goalpara and Chittagong.

The following gives mean hourly variation data for this group of stations. The data are plotted in Fig. 7, Plate XXIV :—

TABLE LX.

HOUR.	Variation from mean of day.	HOUR.	Variation from mean of day.
	"		"
Midnight	—·0070	Noon	+·0214
1	—·0113	13	+·0157
2	—·0171	14	+·0114
3	—·0248	15	+·0097
4	—·0319	16	+·0105
5	—·0352	17	+·0119
6	—·0313	18	+·0125
7	—·0193	19	+·0119
8	—·0007	20	+·0096
	+·0134	21	+·0061
10	+·0230	22	+·0014
11	+·0254	23	—·0033

The following gives the maximum and minimum epochs and the amplitudes of the two oscillations :—

STATION	MORNING OSCILLATION.				AFTERNOON OSCILLATION.				AMPLITUDE.
	Minimum.		Maximum.		Minimum.		Maximum.		
	Epoch.	Variation.	Epoch.	Variation.	Epoch.	Variation.	Epoch.	Variation.	
		"		"		"		"	"
Sibsagar	5 A.M.	—·0479					7 P.M.	+·0260	·0739
Goalpara	5 "	—·0205	11 A.M.	+·0352					·0557
Chittagong	5 "	—·0373	10 A.M.	+·0257	3 P.M.	+·0028	7 P.M.	+·0183	·0630
Mean	5 A.M.	—·0352	11 A.M.	+·0254	3 P.M.	+·0097	6 P.M.	+·0125	·0606

The minimum of the morning oscillation is at 5 A.M. and the maximum at 11 A.M. The amplitude of this is very approximately ·061″. The minimum of the afternoon oscillation is at 3 P.M. and the maximum at about 6 P.M. The amplitude or range of variation in this period is less than ·01″.

The actions producing the variation at these stations are the same as in the case of the previous group, *viz.*, (1) evaporation, (2) diffusion and (3) convective movements. The action of evaporation is very pronounced and the convective movements are feeble.

in the Assam Valley. Hence the peculiar features of the diurnal variation at this group of stations are the large morning oscillation and very small afternoon oscillation.

Diurnal variation, type D.—The diurnal variation of aqueous vapour pressure is of this type at the two following groups of stations:—

1st. group.	2nd. group.
Rangoon.	Cuttack.
Trichinopoly.	Poona.
Bellary.	Belgaum.
Calcutta.	
Aden.	
Hazaribagh.	
Deesa.	

The variation at these stations consists of a double oscillation, the morning oscillation being of small amplitude and the afternoon of largish amplitude. The afternoon oscillation is of exceptionally large amplitude at the second group of stations which are all situated near the sea coast (at distances varying between 40 and 60 miles).

The following table gives mean hourly variation data for these two groups of stations. The data are plotted as representative curves in Fig. 8, Plate XXIV:—

TABLE LXI.

HOUR.	VARIATION FROM MEAN OF DAY.		HOUR.	VARIATION FROM MEAN OF DAY.	
	1st. group.	2nd. group.		1st. group.	2nd. group.
	"	"		"	"
Midnight	+·0191	+·0565	Noon	—·0283	—·1042
1	+·0226	+·0515	13	—·0445	—·1125
2	+·0236	+·0433	14	—·0547	—·1067
3	+·0217	+·0351	15	—·0588	—·0864
4	+·0202	+·0311	16	—·0568	—·0536
5	+·0224	+·0320	17	—·0474	—·0142
6	+·0316	+·0333	18	—·0317	+·0225
7	+·0409	+·0274	19	—·0136	+·0485
8	+·0448	+·0093	20	+·0013	+·0609
9	+·0371	—·0198	21	+·0101	+·0630
10	+·0182	—·0534	22	+·0137	+·0610
11	—·0061	—·0835	23	+·0159	+·0589

The following table gives the epochs of the maximum and minimum phases of the two oscillations and the amplitude of each :—

TABLE LXII.

	Station.	Morning oscillation.				Afternoon oscillation.				Amplitude.
		Minimum.		Maximum.		Minimum.		Maximum.		
		Epoch	Variation	Epoch	Variation.	Epoch.	Variation	Epoch.	Variation.	
			"		"		"		"	
First group.	Rangoon . .	5 A.M.	+·0044	8 A.M.	+·0436	1 P.M.	−·0734	8 P.M.	+·0383	·1170
	Trichinopoly . . .	4 "	+·0293	8 "	+·0440	4 "	−·0727	10 "	+·0248	·1167
	Bellary			8 "	+·0474	4 "	−·0580			·1054
	Calcutta	4 A.M.	+·0122	9 "	+·0388	3 "	−·0667	1 A.M.	+·0269	·1035
	Aden	4 "	+·0062	9 "	+·0241	4 "	−·0498	10 P.M.	+·0189	·0739
	Hazaribagh . . .			6 "	+·0462	3 "	−·0538			·1000
	Deesa			8 "	+·0767	4 "	−·0665			·1432
	Mean .	4 A.M.	+·0202	8 A.M.	+·0448	3 P.M.	−·0588	10 P.M.	+·0137	·1036
Second group.	Cuttack	4 A.M.	+·0304	7 A.M.	+·0384	2 P.M.	−·1031	Midnight	+·0447	·1478
	Poona	4 "	+·0417	5 "	+·0420	1 "	−·1110	9 P.M.	+·0632	·1742
	Belgaum . . .	4 "	+·0212	5 "	+·0226	Noon.	−·1476	8 "	+·0905	·2381
	Mean .	4 A.M.	+·0311	6 A.M.	+·0333	1 P.M.	−·1125	9 P.M.	+·0630	·1755

The diurnal variation of aqueous vapour pressure during this period is of especial interest, more especially in the cases of Poona, Deesa, Belgaum and Cuttack. The data for these stations indicate the very large range of variation which may occur under a combination of favourable conditions. These are, in the present case, large convective movement and the alternation of breezes of widely different hygrometric quality from the land and sea. The combination of this gives a very large decrease during the morning.

The south-west monsoon period.—(First half of the wet monsoon or season).—The south-west humid currents gradually extend over practically the whole of India during the month of June. That month is hence a transitional period during which the humidity conditions change from those of the dry to the wet season. The change occurs earlier at the coast stations than in the interior districts. The diurnal variation of aqueous vapour pressure obtained from the hourly observations for that month is hence a combination in varying proportion of hot weather and south-west monsoon conditions. Similarly the monsoon currents commence to withdraw from North-Western India in the month of September, and hence over that part of India the diurnal variation is a combination of south-west or wet monsoon and dry monsoon conditions. July and August are hence the months fully typical of the south west or wet monsoon over India generally. In Plates XXV to XXX are given curves of aqueous vapour pressure for the months of June and September and for the months of July and August for 28 out of the 29 stations at which hourly observations were recorded.

The following table gives mean data for different provinces or areas :—

TABLE LXIII.

Area.	Normal mean aqueous vapour pressure in June.	July.	August.	September.	Period, June to September.
	"	"	"	"	"
Punjab	·632	·829	·899	·712	·768
Sind	·809	·873	·845	·766	·823
Rajputana	·700	·822	·800	·705	·757
North-Western Provinces and Oudh	·702	·890	·882	·790	·817
Bihar	·892	·963	·957	·924	·934
Central India	·684	·857	·853	·785	·795
Chota Nagpur	·692	·811	·799	·754	·764
Bengal	·932	·947	·940	·927	·937
Central Provinces	·707	·811	·804	·769	·773
Berar	·680	·739	·725	·710	·714
Deccan	·773	·773	·764	·757	·767
Burma	·908	·899	·895	·894	·899
South India	·703	·689	·707	·691	·698
Hill stations Kashmir	·365	·457	·440	·333	·399
Hill stations Punjab and North-Western-Provinces Himalayas.	·416	·547	·548	·460	·493
Hill stations Sikkim Himalayas	·561	·604	·592	·555	·578

The most important feature of the aqueous vapour pressure in July and August is the very slight variation in its amount over by far the greater part of In dia. The only area in which the monsoon influence is slight are the West Punjab, North-West Rajputana and Baluchistan. The following comparative data for six representative stations in Northern India show the uniformity of the absolute humidity conditions during this period :—

Station.	Elevation in feet.	July.	August.	Mean of July and August.
		"	"	"
Rangoon	41	·898	·902	·900
Calcutta	21	·980	·971	·976
Patna	183	·969	·971	·970
Allahabad	309	·941	·937	·939
Roorkee	887	·915	·901	·908
Lahore	702	·848	·846	·847

The following gives corresponding data for the relative humidity :—

Station.	Elevation in feet.	July.	August.	Mean of July and August.
		%	%	%
Rangoon	41	93·1	93·4	93·3
Calcutta	21	86·7	87·6	87·2
Patna	183	83·1	85·6	84·4
Allahabad	309	79·7	82·5	81·1
Roorkee	887	79·4	81·6	80·5
Lahore	702	63·3	67·0	65·2

Another important feature is the small diurnal range of the aqueous vapour pressure, due to the meteorological conditions of the period. This feature makes it somewhat difficult to classify the diurnal variation at the 29 stations under discussion according to the selected types.

Diurnal variation, type A.—The diurnal variation belongs to type A at three groups of stations, *viz.* :—

1st. group.	2nd. group.	3rd. group.
Chittagong.	Sibsagar.	Poona.
Pachmarhi.	Dhubri.	Belgaum.
Rangoon.		
Bombay.		

The first group includes the coast stations under the full influence of the south-west monsoon currents. The second group includes the Assam stations and the third group, the West Deccan stations under the lee of the West Ghâts. The following table gives mean hourly variation data for each of these three groups of stations (*vide* Figs. 9, 10 and 11, Plate XXIV).

TABLE LXIV.

Hour.	Variation from mean of day.		
	1st group.	2nd group.	3rd group.
	"	"	"
Midnight	—·0106	+·0004	—·0051
1	—·0146	—·0067	—·0064
2	—·0178	—·0154	—·0096
3	—·0217	—·0243	—·0138
4	—·0251	—·0312	—·0164
5	—·0265	—·0338	—·0149
6	—·0233	—·0310	—·0085
7	—·0146	—·0236	+·0008
8	—·0027	—·0137	+·0092

TABLE LXIV—*concld.*

Hour.	Variation from mean of day.		
	1st group.	2nd group.	3rd group.
	"	"	"
9	+·0090	—·0038	+·0135
10	+·0188	+·0042	+·0138
11	+·0250	+·0093	+·0122
Noon	+·0285	+·0114	+·0112
13	+·0308	+·0117	+·0119
14	+·0288	+·0114	+·0127
15	+·0235	+·0120	+·0117
16	+·0156	+·0141	+·0079
17	+·0056	+·0172	+·0025
18	—·0014	+·0199	—·0026
19	—·0051	+·0207	—·0057
20	—·0053	+·0190	—·0068
21	—·0052	+·0154	—·0066
22	—·0058	+·0109	—·0059
23	—·0078	+·0061	—·0052

The minimum epoch of the first group of stations is at 5 A.M. and the maximum at 1 P.M. The variation is similar in character and is parallel with the diurnal variation of the winds in the coast districts, due to the slight to moderate heating of the interior during the day hours. The mean amplitude of the oscillation is ·057″ and is hence small compared with the mean actual vapour pressure which is ·851″.

The epoch of the minimum at the Assam stations is also at 5 A.M. and the maximum at 7 P.M. At these stations the variation appears to be in part due to local evaporation and in part to diurnal variation in the strength of the winds.

In the case of Poona and Belgaum the minimum occurs at 4 A.M. There is at these two stations a very slight fall from 10 A.M. to noon followed by a corresponding rise until 2 P.M. This is almost certainly the result of slight convective movement in the West Deccan superimposed upon the diurnal variation in the strength of the monsoon winds similar to that at the coast stations. It is interesting to compare the actual curves of Poona and Belgaum for July and August.

Diurnal variation, type B.—The diurnal variation in this season belongs to type B (a double oscillation of nearly equal amplitudes) at the following stations:—

Lahore,	Kurrachee,
Agra,	Nagpur,
Jaipur,	Bellary,
Deesa,	Trichinopoly and Leh.

The following table gives hourly variation data for this group of stations. The curve representing the data is given in Fig. 12, Plate XXIV.

TABLE LXV.

Hour.	Variation from mean of day.	Hour.	Variation from mean of day.
	"		"
Midnight	+·0027	Noon	+·0031
1	—·0002	13	+·0016
2	—·0045	14	—·0005
3	—·0092	15	—·0042
4	—·0120	16	—·0072
5	—·0108	17	—·0074
6	—·0053	18	—·0040
7	+·0011	19	+·0015
8	+·0076	20	+·0057
9	+·0091	21	+·0076
10	+·0071	22	+·0072
11	+·0041	23	+·0054

The diurnal variation at these stations is the resultant of the actions of evaporation, diffusion and convective movement. At Bellary and Trichinopoly where the convective movement is moderate in amount, the two oscillations are of nearly equal amplitude. At Lahore, on the other hand, where the convective action is large, the amplitude of the afternoon oscillation is greater than that of the morning At Nagpur, Jaipur, Agra, Lucknow and Deesa, the amplitudes of both oscillations are small, but that of the morning is slightly greater than that of the afternoon. The character of the variation hence depends largely upon geographical position with respect to the monsoon currents.

Diurnal variation, type C.—The diurnal variation of aqueous vapour pressure belongs to type C at the following stations in July and August:—

Cuttack.	Lucknow.	Dhubri.
Jubbulpore.	Patna.	Roorkee.
Allahabad.	Hazaribagh.	Aden.

TABLE LXVI.

Hour.	Variation from mean of day.	Hour.	Variation from mean of day.
	"		"
Midnight	—·0027	Noon	+·0126
1	—·0068	13	+·0134
2	—·0115	14	+·0115
3	—·0148	15	+·0069
4	—·0186	16	+·0015
5	—·0175	17	—·0014
6	—·0123	18	—·0007
7	—·0050	19	+·0026
8	+·0016	20	+·0058
9	+·0061	21	+·0064
10	+·0087	22	+·0045
11	+·0107	23	+·0011

The curve plotted from these figures is given in Plate XXIV, Fig. 13.

The aqueous vapour pressure at this group of stations has its minimum value at 4 A.M. It thence increases to 1 P.M., after which it falls slightly to 5 P.M. and thence increases to the secondary maximum at 9 P.M. The total range of variation is ·032″ or less than 5 per cent. of the mean vapour pressure of the period.

The chief factors in determining the diurnal variation at these stations are evaporation and diffusion. Convective action has a very slight effect at these stations in this season. It is shown by the slight depression in the afternoon, the maximum effect being ·02″ between 5 P.M. and 6 P.M.

The Retreating south-west monsoon period (*second half of the wet or south-west monsoon*).—During this period the south-west monsoon currents gradually withdraw from the Indian land and sea areas and are replaced by land winds, very feeble at first but gradually increasing to moderate strength in December. The change usually occurs in the third or fourth week of September in Upper India, in October over North-Eastern and Central India, in November over Burma and the South Deccan and North Madras and in December over South India. The humidity conditions hence change from those characteristics of the humid weather of the south-west or wet monsoon to those of the dry or north-east monsoon. Over the greater part of Northern and Central India the diurnal variation of aqueous vapour is similar to that of the cold weather period, but the range or amplitude is smaller, more especially in North-Eastern India.

Land and sea breezes set in on the west coast of India during the period. These influence the diurnal variation considerably, more especially at stations near the inner edge of the narrow coast belt over which these alternating winds obtain.

The following table gives mean aqueous vapour pressure data of the period for different provinces or areas :—

TABLE LXVII.

AREA.	NORMAL MEAN AQUEOUS VAPOUR PRESSURE IN			
	October.	November.	December.	Period, October to December.
	″	″	″	″
Punjab	·447	·313	·261	·340
Sind	·533	·374	·303	·403
Rajputana	·436	·300	·269	·335
North-Western Provinces and Oudh	·521	·355	·297	·391
Bihar	·726	·501	·399	·542
Central India	·532	·335	·284	·384
Chota Nagpur	·539	·360	·274	·391
Bengal	·808	·605	·461	·625
Central Provinces	·568	·390	·321	·426
Berar	·547	·403	·328	·426
Deccan	·706	·591	·500	·599
Burma	·880	·781	·651	·771
South India	·678	·608	·523	·603
Hill stations Kashmir	·208	·160	·128	·165
Hill stations Punjab and North-Western Provinces Himalayas	·273	·195	·157	·208
Hill stations Sikkim Himalayas	·422	·301	·234	·319

Diurnal variation, type A.—The diurnal variation of aqueous vapour pressure during this period is of type A at the coast stations of Kurrachee, Bombay and Trivandrum (*vide* Fig. 14, Plate XXIV).

The following gives mean hourly variation data for this group of stations:—

TABLE LXVIII.

Hour.	Variation from mean of day.	Hour.	Variation from mean of day.
	"		"
Midnight	+·0007	Noon	—·0191
1	—·0070	13	—·0019
2	—·0154	14	+·0091
	—·0246	15	+·0243
4	—·0340	16	+·0369
5	—·0416	17	+·0432
6	—·0440	18	+·0477
7	—·0360	19	+·0485
8	—·0281	20	+·0451
9	—·0227	21	+·0344
10	—·0205	22	+·0201
11	—·0209	23	+·0081

The variation at these stations is practically a single oscillation, the maximum of which is at 7 P.M. and the minimum at 6 A.M. The range is large, averaging ·0925" for the group.

Diurnal variation, type B.—The diurnal variation is of the type B at the following stations (*vide* Fig. 15, Plate XXIV):—

Lahore.	Hazaribagh
Roorkee.	Dhubri.
Agra	Deesa.
Lucknow.	Jaipur.
Allahabad.	Jubbulpore
Patna.	Nagpur.

This group includes all the plains stations in the interior of Northern and Central India.

The following gives mean hourly variation data for this group of stations:—

TABLE LXIX.

HOUR.	Variation from mean of day.	HOUR.	Variation from mean of day.
Midnight	+·0027	Noon	—·0030
1	—·0015	13	—·0142
2	—·0071	14	—·0194
3	—·0134	15	—·0151
4	—·0192	16	—·0027
5	—·0215	17	+·0113
6	—·0188	18	+·0220
7	—·0110	19	+·0255
8	—·0001	20	+·0226
9	+·0092	21	+·0166
10	+·0083	22	+·0108
11	+·0076	23	+·0061

The variation at these stations consists of a double oscillation. The minima values of the vapour pressure occur at 5 A.M. and 2 P.M., and the maxima values at 9 A.M. and 7 P.M.

The amplitude of the variation varies slightly at different stations.

The following table gives the epochs of the maxima and minima phases, and the amplitude or absolute range at each of these stations:—

TABLE LXX.

STATION.	MORNING OSCILLATION.				AFTERNOON OSCILLATION.				Amplitude.
	Minimum.		Maximum.		Minimum.		Maximum.		
	Epoch.	Variation.	Epoch.	Variation.	Epoch.	Variation.	Epoch.	Variation.	
		"		"		"		"	"
Jubbulpore	5 A.M.	—·0275	10 A.M.	+·0142	2 P.M.	—·0154	8 P.M.	+·0299	·0574
Nagpur	5 "	—·0198	10 "	+·0227	3 "	—·0150	9 "	+·0130	·0425
Allahabad	5 "	—·0164	10 "	+·0078	2 "	—·0253	6 "	+·0391	·0644
Agra	5 "	—·0138	10 "	—·0014	2 "	—·0329	7 "	+·0363	·0692
Lucknow	5 "	—·0278	10 "	+·0210	2 "	—·0236	7 "	+·0308	·0586
Patna	5 "	—·0275	10 "	+·0075	2 "	—·0076	7 "	+·0260	·0535
Hazaribagh	5 "	—·0086	8 "	+·0130	1 "	—·0219	8 "	+·0262	·0481
Lahore	5 "	—·0232	10 "	+·0220	2 "	—·0310	7 "	+·0366	·0598
Dhubri	6 "	—·0350	11 "	+·0194	3 "	—·0092	10 "	+·0276	·c626

TABLE LXX—concld.

STATION.	MORNING OSCILLATION.				AFTERNOON OSCILLATION.				Amplitude.
	Minimum		Maximum.		Minimum.		Maximum		
	Epoch	Variation.	Epoch.	Variation.	Epoch.	Variation.	Epoch	Variation.	
		"		"		"		"	"
Jaipur . . .	4 A.M.	—·0220	9·30 A.M.	+·0115	2 P.M.	—·0200	6 P.M.	+·0100	·0620
Roorkee . . .	5·30 „	—·0305	10 „	+·0320	2 „	—·0160	6 „	+·0190	·0625
Deesa	5 „	—·0100	9·30 „	+·0035	2 „	—·0230	7 „	+·0210	·0440
Mean .	5 A.M.	—·0215	9 A.M.	+·0092	2 P.M.	—·0194	7 P.M.	+·0255	·0470

The variation at these stations is evidently chiefly, if not entirely, due to the actions of (1) evaporation, (2) diffusion, and (3) convective movement. These actions are slightly more vigorous in the Central Provinces and the eastern districts of the North-Western Provinces than in the Punjab, Rajputana and the western districts of the North-Western Provinces. Hence the considerable variation in the range of vapour pressure at these stations.

Diurnal variation, type C.—The diurnal variation is of type C (*i.e.*, is a double oscillation, of which the afternoon oscillation is of small amplitude compared with that of the morning oscillation) at—

1ST group.	2ND group
Sibsagar.	Pachmarhi.
Goalpara.	Chittagong.
	Rangoon.
	Trichinopoly

The following table gives the mean hourly variations at these two groups of stations plotted in Fig. 16, Plate XXIV:—

TABLE LXXI.

HOUR.	VARIATION FROM MEAN OF DAY		HOUR.	VARIATION FROM MEAN OF DAY.	
	1st group.	2nd group.		1st group.	2nd group
	"	"		"	"
Midnight . . .	—·0123	—·0048	Noon	+·0426	+·0121
1 . . .	—·0218	—·0097	13	+·0334	+·0063
2 . . .	—·0317	—·0155	14	+·0244	+·0042
3 . . .	—·0398	—·0224	15	+·0212	+·0066
4 . . .	—·0466	—·0290	16	+·0232	+·0114
5 . . .	—·0517	—·0323	17	+·0256	+·0156
6 . . .	—·0516	—·0291	18	+·0244	+·0173
7 . . .	—·0418	—·0185	19	+·0202	+·0164
8 . . .	—·0209	—·0033	20	+·0139	+·0135
9 . . .	+·0066	+·0107	21	+·0085	+·0095
10 . . .	+·0309	+·0183	22	+·0032	+·0048
11 . . .	+·0435	+·0179	23	—·0032	+·0040

The following table gives the epochs of the maxima and minima values and also the absolute diurnal range at each of these six stations :—

TABLE LXXII.

Station.	Morning oscillation.				Afternoon and evening oscillation.				Amplitude.
	Minimum.		Maximum.		Minimum.		Maximum.		
	Epoch.	Variation.	Epoch.	Variation.	Epoch.	Variation.	Epoch.	Variation.	
		"		"		"		"	"
Chittagong . . .	5 A.M.	—·0516?	10 A.M.	+·0335?	2 P.M.	+·0150	4 P.M.	+·0251	·0851
Rangoon . . .	5 „	—·0439	11 „	+·0272	3 „	+·0018	7 „	+·0274	·0713
Trichinopoly . .	5 „	—·0138?	10 „	+·0235	3 „	—·0054?	8 „	+·0179	·0373
Pamban? . .	4 „	—·0066?	10 „	+·0050?	1 „	+·0016	6 „	+·0109?	·0105
Mean .	5 „	—·0275?	10 „	+·0153?	2 „	+·0042	6 „	+·0173	·0506?
Sibsagar . . .	5 „	—·0684?	11 „	+·0439?	2 „	+·0217	6 „	+·0468	·1152
Goalpara . . .	5·30 „	—·0285?	Noon.	+·0260?	3 „	—·0030?	11 „	+·0030?	·0315
Mean .	5 A.M.	—·0517	11 A.M.	+·0435	3 P.M.	—·0212	5 P.M.	+·0256	·0952

The morning oscillation is of greater amplitude than the afternoon oscillation. The amplitude of the former averages ·095", and of the afternoon ·047", almost exactly half of the former. The minimum and maximum values of the morning oscillation are at 5 A.M. and 11 A.M. and of the afternoon at 3 P.M. and 5 P.M. respectively.

Diurnal variation, type D.—The diurnal variation belongs to type D at the following stations situated at a distance of 40 to 70 miles from the coast :—

Belgaum.	Cuttack
Poona.	Calcutta.

and also at Aden and Bellary.

The following gives mean variation data of the first four stations (plotted in Fig. 17, Plate XXIV).

TABLE LXXIII.

Hour.	Variation from mean of day.	Hour.	Variation from mean of day.
	"		"
Midnight	+·0171?	Noon	—·0255?
1	+·0155?	13	—·0258?
2	+·0104?	14	—·0334
3	+·0022?	15	—·0377?
4	—·0031?	16	—·0325?
5	—·0045?	17	—·0125?
6	—·0076?	18	+·0104?
7	+·0058?	19	+·0270
8	+·0164?	20	+·0209?
9	+·0155?	21	+·0256?
10	—·0024?	22	+·0243?
11	—·0113?	23	+·0177?

The morning oscillation has its minimum at 5 A.M. and maximum at 8 A.M. The amplitude is ·013″. The minimum of the afternoon oscillation is at 2 P.M. and the maximum at 8 P.M., and its amplitude is ·073″, nearly six times as large as that of the morning oscillation.

The following gives the maxima and minima epochs and absolute range at each of these stations :—

TABLE LXXIV.

Station.	Morning oscillation.				Afternoon and evening oscillation.				Amplitude.
	Minimum.		Maximum.		Minimum.		Maximum.		
	Epoch.	Variation.	Epoch.	Variation.	Epoch.	Variation.	Epoch.	Variation.	
		″		″		″		″	″
Poona . . .			7 A.M.	+·0272	2 P.M.	—·0490			·0762
Cuttack . . .	5 A.M.	—·0233	9 „	—·0012	1 „	—·0431	7 P.M.	+·0475	·0906
Belgaum . . .	4 „	—·0055	8 „	+·0166	2 „	—·0391	8 „	+·0259	·0650
Bellary . . .	5 „	—·0046	9 „	+·0319	4 „	—·0263	10 „	+·0070	·0582
Calcutta . . .	5 „	—·0097	8 „	—·0022	2 „	—·0435	7 „	+·0410	·0845
Aden	5 „	+·0076	8 „	+·0141	2 „	—·0378	10 „	+·0217	·0595
Mean .	5 A.M.	—·0043	8 A.M.	+·0084	2 P.M.	—·0434	8 P.M.	+·0299	·0733

The chief factor in producing the diurnal variation at these stations in addition to evaporation and diffusion is the alternating influence of the land and sea breezes. Probably also convective movement contributes to a slight extent.

General Discussion of most important features of the diurnal variation of the aqueous vapour pressure and their causes.— The following is a brief discussion of certain interesting features disclosed by the examination of the curves in Plates XXIV to XXXI, representing the diurnal variation of aqueous vapour pressure at different seasons of the year in different parts of India.

The simplest type of the diurnal variation of aqueous vapour pressure is that observed at coast stations in India, more especially Trivandrum, Bombay and Kurrachee. During the greater part of the dry season this variation is due to the alternation of land and sea breezes, and the variation is large and pronounced. In the wet season it is due to the diurnal variation of the indraught across the Indian coasts into India, determined by the moderate to considerable diurnal variation of temperature in the interior of the Peninsula and in North-Western India.

The annual curves for the stations of Trivandrum, Bombay and Kurrachee in Plates XXVIII to XXX show the general features of this type fully. The minimum pressure is usually observed shortly after sunrise at about 7 A.M. and the maximum shortly after sunset at about 7 P.M. The amplitude of the variation is, as already stated, large in the dry weather and appears to be greatest on the Sind and Kathiawar coasts. It decreases southwards along the Konkan and Malabar coasts. It is greatest on the Sind coast in November, at Bombay in April and at Trivandrum in March.

The diurnal variation at the West Coast stations in the wet monsoon is very slight, the amplitude being barely two per cent. of the mean vapour pressure, but is of the same type as in the dry monsoon.

It may be noticed that there is a marked tendency at the hill stations in the interior and at the plains stations when the weather is more or less continuously clouded in the rainy or wet season for the diurnal variation to resemble that of the West Coast stations, in other words, to consist of a single oscillation, the minimum value of which is in the morning and the maximum in the afternoon or evening, and the amplitude of which is small, more especially when compared with the actual mean vapour pressure of the period. As examples of this may be cited the following:—

Station.	Period or Month.
Allahabad.	August.
Calcutta.	July and August.
Cuttack.	Ditto.
Hazaribagh.	Ditto.
Jaipur.	August.
Jubbulpore.	July and August.
Nagpur.	Ditto.
Patna.	Ditto.
Roorkee.	August

The amplitude of the variation at these stations during the periods stated is small ranging between ·02″ and ·04″. The variation due to the temperature changes is very small in these months and generally less than ·01″.

The type of variation observed throughout the greater part of the year at the Assam stations and also at Srinagar in the Kashmir Valley throughout the whole year also belongs to the same type. The chief feature at the Assam stations is a single oscillation the minimum of which is at about sunrise and the maximum in the afternoon, usually about 3 or 4 P. M. The variation at these stations is chiefly due to the processes of evaporation and diffusion. The curves for Srinagar given in Plate XXXI show this type of variation in its most pronounced form. The curves of Sibsagar for June and of Goalpara and of Dhubri for July are good examples. In the drier months (from October to March) there is a slight depression in the curves for these stations from about noon to 6 P. M., greatest at 2 to 3 P. M. (*vide* the Sibsagar curve, Plate IV, in the discussion of the Sibsagar hourly observations). This is evidently due to convective action which is most vigorous in Assam in November, December and January when skies are most free from cloud. A consideration of the curves suggests that a free hand curve can be drawn for the period of the day in which convective action occurs which will, with the remainder of the curves, give the resultant effect of evaporation and diffusion solely, whilst the differences between the actual curve and the free hand curve for the period of convective action will give an estimate of the effect of that action on the aqueous vapour pressure.

The curves for Leh, which also belong to this type (A), suggest that the diurnal variation in the aqueous vapour pressure at that station in the months of December January, February and March is almost solely due to evaporation and diffusion. The curves for the months of June to September show a depression in the day hours from 8 A.M. to 3 or 4 P.M., similar in character to that noticed in the Sibsagar aqueous vapour pressure curves for the cold weather months. This is almost certainly due either to convective movement or the strong valley winds which are reported to prevail during the hotter hours of the day in the Indus Valley. The temperature effect is very small at Leh, as the actual amount of the aqueous vapour is small.

The diurnal variation of aqueous vapour pressure at stations in the interior of India throughout the year, with a few exceptions, is a double oscillation, due to the superimposition of a day effect of convective movement upon a 24-hour period effect due to evaporation and diffusion. The curves of the following stations belong to this type for the whole year (with the exception, in some cases, of July and August) :—

Agra.	Lucknow.	Allahabad.	Nagpur.
Dhubri.	Patna.	Jaipur.	Roorkee.
Jubbulpore.	Trichinopoly.	Lahore.	

An examination of the curves of these stations suggests the possibility of separating the effects of evaporation and diffusion from those of convection curves.

An examination of the curves given in Plates XXV to XXX shows that they may practically, without exception, be resolved into the sum of two curves—one representing an effect of 24-hour period and the other of about 12-hour period. A large number of these, including figures 1, 2, 7, 8, 10, 11, 13, 14, 16, 17, 19, 20, 25, 26, 28, 29 in Plate XXV, figures 1, 2, 4, 5, 7, 8, 25 and 26 in Plate XXVI, figures 4 and 5 in Plate XXVII, figures 1 to 3, 7 to 9, 10 to 21 and 25 to 30 in Plate XXVIII, figures 1 to 9 and 25 to 27 in Plate XXIX and figures 4 to 6 in Plate XXX, are the combination of curves for the actions of evaporation and diffusion and for convective actions. In each of these figures a curve in broken line for the day hours has been added, and this with the remainder of the curves probably represents closely the effects of evaporation and diffusion and perhaps the slight general day influx from the sea in certain seasons. The ordinates between the broken curves and the corresponding portions of the original curves represent the effect of the day convective actions in introducing drier air either by horizontal or vertical air movement, and thus diminishing the aqueous vapour pressure. A glance at the monthly curves of any of the stations in the interior of India will show that free hand curves can be drawn which probably represent very approximately the combined effect of evaporation and diffusion. This supposition, if correct, enables the diurnal variation of that effect to be measured and also the additional effect of convective action.

The following gives measures of the diurnal variation of the aqueous vapour pressure due to the varying actions of evaporation and diffusion throughout the day for each of the four seasons at thirteen selected stations obtained by the process described above :—

Station.	Probable amplitude of variation due to effects of evaporation and diffusion.			
	Cold weather.	Hot weather.	July and August.	Retreating south-west monsoon.
	"	"	"	"
Sibsagar	·11	·10	·08	·14
Goalpara	·07	·07	·08	·11
Patna	·08	·08	·07	·07
Hazaribagh	·04	·04	·05	·05
Dhubri	·06	·05	·05	·09
Roorkee	·07	·06	·07	·08
Allahabad	·07	·05	·06	·07
Agra	·06	·06	·05	·06
Lucknow	·07	·08	·06	·08
Jaipur	·06	·07	·04	·08
Lahore	·08	·07	·04	·08
Jubbulpore	·06	·03	·05	·08
Nagpur	·05	·05	·04	·07

In these figures no allowance has been made for the variation of aqueous vapour pressure with increase or decrease of temperature.

If the figures may be accepted as giving an approximately correct result of the action of evaporation and diffusion, they establish that the diurnal variation due to these two effects is practically identical in amount over the whole of the interior of Northern India and also is almost uniform in amount throughout the year. The mean or average effect of the high temperature, low humidity and strong winds of the dry season is slightly greater than that of moderate temperature, high humidity, much cloud and moderate winds of the rainy season.

The data also show that these processes have throughout the whole year a larger effect in Assam than in any other part of India. This is probably due to the fact that it is a river valley almost completely encircled and shut in by mountain or hill ranges and with a very large river bed (in proportion to its extent) and surface soil more or less heavily charged with moisture. The Kashmir Valley presents the same features as the Assam Valley in a very pronounced and almost unique form, and has in addition a considerable number of lakes, jheels, and marshes which add largely to the water surface in the valley. I have hence had the data for Srinagar worked out for comparison with Sibsagar, Leh and Pachmarhi. The following gives the results for the mean day of the year :—

TABLE LXXV.

Hour.	Diurnal variation of vapour pressure on the mean day of the year at			
	Srinagar.	Sibsagar.	Leh.	Pachmarhi.
	"	"	"	"
Midnight	—·051	—·009	—·005	—·008
1	—·065	—·018	—·008	—·012
2	—·077	—·027	—·010	—·013
3	—·088	—·036	—·012	—·015
4	—·100	—·045	—·014	—·015
5	—·106	—·052	—·015	—·016
6	—·104	—·054	—·012	—·013
7	—·087	—·039	—·001	—·004
8	—·055	—·019	+·006	+·008
9	—·024	+·003	+·007	+·002
10	+·009	+·018	+·007	+·006
11	+·036	+·023	+·010	+·009
Noon	+·062	+·024	+·011	+·011
13	+·087	+·025	+·012	+·011
14	+·111	+·024	+·013	+·008
15	+·126	+·023	+·011	+·007
16	+·131	+·025	+·008	+·004
17	+·113	+·032	+·005	+·001
18	+·083	+·036	+·003	+·009
19	+·046	+·031	0	+·007
20	+·019	+·023	—·002	+·007
21	—·003	+·016	—·003	—·003
22	—·020	+·007	—·002	0
23	—·035	0	—·004	—·004

The preceding data when charted as curves show that the Srinagar curve is unique in its amplitude, but that it agrees in its general form with those of Sibsagar, Pachmarhi and Leh.

As stated before, the differences of the ordinates of the actual and hypothetical curves give an estimate of the effect of convective movement. The following is a statement for the same stations, for which data are given in the table in page 152:—

Station.	Maximum amplitude due to convective movement in					Maximum value and month.	Minimum value and month.
	Cold season.	Hot season	Rainy season.	Retreating south-west monsoon season.	Year.		
	"	"	"	"	"	"	"
Sibsagar	·03	·03	·02	·04	·02	·05 in November	·01 in June
Goalpara	·06	·05	·04	·07	·04	·06 in February, March and August.	·01 in July
Patna	·04	·0[illegible]	·02	·05	·04	·09 in May	·01 in July
Hazaribagh	·06	·12	·02	·06	·07	·15 in April and May.	·02 in July and August.
Dhubri	·06	·06	·02	·06	·05	·11 in March	·02 in May and June.
Roorkee	·07	·10	·05	·06	·06	·13 in April	·03 in August
Lahore	·07	·11	·08	·09	·08	·16 in June	·05 in January and December.
Lucknow	·05	·08	·03	·08	·06	·12 in October	·03 in July and August.
Agra	·06	·11	·04	·07	·08	·13 in May	·03 in August
Jaipur	·05	·09	·04	·07	·06	·15 in May	·03 in August
Allahabad	·06	·11	·03	·08	·06	·14 in May	·02 in July
Jubbulpore	·05	·08	·02	·07	·05	·12 in May	·01 in July and August.
Nagpur	·02	·07	·03	·06	·05	·11 in May	·02 in July

The results, it will be seen, are fairly consistent. The effect of convective action is small in the south-west monsoon period, except in the East and Central Punjab, where the monsoon prevails in an intermittent manner. It is generally slightly larger in the period of the retreating south-west monsoon than in the cold weather season. It is, on the other hand, large at all stations in the hot weather and is more than twice as great in May (when it is generally greatest in the interior) as it is on the average of the whole year.

At the majority of the remaining stations which are all at a moderate distance from the coast, including Deesa, Calcutta, Cuttack, Chittagong, Rangoon, Poona and Belgaum for the period October to June, the diurnal variation is, except during the rains, due to a combination of the effects of at least four actions or factors, *viz.* :—

(1) Evaporation.
(2) Diffusion.
(3) Convective movement.
(4) Land and sea breezes.

The effect of (1) and (2) is probably similar in amount to what it was found to be for stations in the interior of Northern India. It is hence possible to ascertain the combined effects of the actions (3) and (4) in varying the aqueous vapour pressure during the day. As the change from the land to the sea breezes and, *vice versâ*, modifies to some extent the effect of the convective movements, it is hardly possible to separate the combined effect into its two components. As the prevalence of the land breeze tends to diminish the humidity and the sea breeze to increase the aqueous vapour pressure, the double or conjoint action of convective air movements and the land and sea breezes produces an oscillatory effect, the maximum and minimum values of which will depend upon the position and distance of the place from the sea coast. The amplitude of the variation, due to alternation of land and sea breezes as also of that due to the convective movement, will be greatest in the hot weather, and where the phases coincide approximately the combined variation will be very large. This is especially the case at Belgaum, and to a slightly less extent at Poona, Deesa and Cuttack. The diurnal variation of the aqueous vapour pressure at these stations is hence of peculiar interest.

The following tables give the probable amplitude or total range of vapour pressure due to actions (1), (2) and (4) at these stations in each month of the hot weather period :—

Station.	Probable amplitude of variation due to (1), (2) and (4).				Probable amplitude of variation due to (1) and (2).	Probable amplitude of variation due to (4).
	March.	April.	May.	Mean, March to May.		
	"	"	"	"	"	"
Belgaum	·12	·11	·10	·11	·06	·05
Poona	·06	·07	·07	·07	·05	·02
Deesa	·07	·11	·11	·10	·06	·04
Cuttack	·06	·06	·05	·06	·05	·01

Station.	Period of minimum value due to combined actions (3) and (4).		
	March.	April.	May.
Belgaum	Noon	0·30 P.M.	0·30 P.M.
Poona	3 P.M	1 P.M.	1·30 P.M.
Deesa	3·30 P.M.	3·30 P.M.	4 P.M.
Cuttack	3 P.M.	2 P.M.	3 P.M.

Station.	Probable amplitude of variation due to (3) and (4).				Probable amplitude of variation due to (4).	Probable amplitude of variation due to (3).
	March.	April.	May.	Mean, March to May.		
	"	"	"	"	"	"
Belgaum	·25	·30	·24	·26	·05	·21
Poona	·18	·23	·25	·23	·02	·21
Deesa	·08	·19	·24	·17	·04	·13
Cuttack	·20	·26	·12	·19	·01	·18

The following gives data of the probable amplitude of variation due to actions (3) and (4) for each hour of the day from 8 A.M. to 8 P.M. at Belgaum and Poona :—

Hour.	Belgaum.			Poona.		
	Probable amplitude of variation due to (3) and (4).			Probable amplitude of variation due to (3) and (4).		
	March.	April	May.	March.	April	May
	"	"	"	"	"	"
8 A.M.	·02	·10	·08	·05	·06	·06
9 "	·12	·15	·13	·09	·11	·11
10 "	·17	·22	·18	·11	·16	16
11 "	·22	·28	·22	·14	·19	20
Noon	·24	·30	·24	·16	·21	·23
1 P.M.	·25	·30	·23	·17	·23	·25
2 "	·24	·26	·20	·18	·22	·24
3 "	·23	·20	·16	·18	20	·22
4 "	·19	·12	·12	·17	·16	·18
5 "	·13	·06	·09	·14	·11	·13
6 "	0	·04	·08	·11	·06	·08
7 "	0	·02	·06	·07	·01	05
8 "	0	0	·04	·04	0	·03

Summary of conclusions.—The following is a summary of the conclusions :—

1st.—For the interior of Northern India—

(1) The processes of evaporation and diffusion have their greatest effect in the hot weather and early dry weather seasons, and their least effect in the rains at stations in this area.

(2) Convective action produces its greatest effect in the hot weather. The effect is moderate in amount in the early dry weather and the cold weather and is very slight in the south-west monsoon season.

(3) The effect of evaporation is larger at the eastern than at the western stations in the Gangetic Plain in the dry season. The variations from station to station are, however, small.

2nd.—For the interior stations of the Peninsula—

(1) The processes of evaporation and diffusion give rise to a variation in the dry season similar in its law to that in Northern India, but the amplitude is slightly greater. It is hence probable that a small portion of this may be due to a slight general increase and decrease accompanying the diurnal variation of the influx from the adjacent seas, and more especially the land and sea winds which prevail in the Bombay and Madras coasts during that season.

(2) The variation due to convection is as small in the months of July and August as in Northern India. It is also small in amount in the retreating south-west monsoon period due to the large cloud amount which usually obtains in that area during this period. The variation, however, in the remaining five months of the year, January to May, due to this process is very large and is considerably larger than in the hottest regions of North-Western and Central India.

3rd.— For Assam—

The curves for the Assam stations are peculiar. The chief features are a large morning oscillation and a very small afternoon variation due to convective action. The effect of evaporation is greater in Assam than in any other portion of India except Kashmir. The distance from Sadiya to Dhubri is about 500 miles by river. Dibrugarh, near the head of the valley, is only 400 feet above sea level. The river stretches over a wide expanse of bed and the whole country up to the foot of the hills is extremely flat and covered with vegetation and forest. It is completely hemmed in by mountains except at its eastern extremity. The water surface is very large, and the conditions are very favourable for evaporation and for the retention of the products of evaporation in the superjacent atmosphere. An examination of the curves treated similarly to those already discussed shows—

1st.—The greater intensity of the action of evaporation in the morning hours than in other parts of India.

2nd.—The very slight effect of convective movements in the valley.

4th.—For the coast stations—

The curves given in Plates XXV to XXX for these stations are the means of data showing considerable differences, the causes which have been already stated. The resolution or decomposition of these curves into two, giving—

(1) the effect of evaporation and diffusion,

(2) the effect of the variation of the winds, more especially of the land and sea breezes,

is difficult, as it is most probable that the variations of aqueous vapour pressure, due to evaporation and diffusion at stations in the immediate neighbourhood of large sea areas, differ considerably in amount and probably in character from those in the interior.

Assuming, however, that the results of the first action at these stations are similar in character and amount to those at the neighbouring stations in the interior and separating this effect from the total effect it follows that the effect of the variation of the winds is small in the hot weather and rainy seasons proper at Bombay and Kurrachee and is, on the other hand, considerable in the period from October to February when there is a large shift of winds from land to sea directions and, *vice versâ*, during the day. These results are roughly indicated in Figs. 4 and 5, Plates XXV and XXVIII, and in Figs. 22 and 23, Plates XXVI and XXIX. An examination of the curves for Chittagong and Rangoon confirms these results.

Comparison of the Besselian resolution of the aqueous vapour pressure with that for pressure, temperature and cloud.—The preceding discussion has shown that the chief actions contributing to produce the diurnal variation of aqueous vapour pressure are—

(1) Evaporation.
(2) Diffusion.
(3) Convective action.
(4) Land and sea breezes.
(5) Diurnal variation of air movement generally.

The first, second, fourth and fifth factors or elements have a well defined oscillatory change of 24 hours period. The third factor is a discontinuous action, and practically restricted to the day hours from about 8 A.M. to 7 or 8 P. M., and varying considerably in its intensity and slightly in its period in different seasons.

The Besselian resolution into simple harmonic elements of 24, 12, 8 and 6 hours periods is hence a mathematical resolution only, and is of little value in suggesting the character, period or magnitude of the physical actions giving rise to the variation.

A comparison has been made between the elements of the Besselian resolution of the diurnal variation of aqueous vapour pressure, cloud and temperature. The following gives the more important inference:

First component.—The most noteworthy feature of the first component in the case of the aqueous vapour pressure is the extreme irregularity in the epoch of the maximum and minimum phases. They vary as largely from place to place in the same month as they do from month to month at the same place. In the present discussion it will be convenient to arrange the stations in two groups according to their position with respect to the sea coast. Group A includes all stations affected more or less by considerable variations in the strength of the sea winds or by alternating land and sea breezes and also the Assam stations, and includes the following stations :—

Calcutta.	Deesa.
Kurrachee.	Chittagong.
Poona.	Allahabad.
Trivandrum.	Belgaum.
Rangoon.	Trichinopoly.
Aden.	Sibsagar.
Dhubri.	Goalpara.

Group B includes stations in the interior of India which are practically outside the influence of sea breezes in the dry season, and includes—

Hazaribagh,	Patna,
Allahabad,	Lucknow,
Agra,	Roorkee,
Lahore,	Jaipur,
Jubbulpore,	Nagpur,

and perhaps Bellary.

The epoch of the maximum of u, at stations in group B generally occurs from November to February between 4 P.M. and 6 P.M., and in the hot weather in the early morning hours. During the humid monsoon months it occurs at the great majority of stations in the afternoon hours from 3 P.M. to 6 P.M.

The amplitude of u varies largely and irregularly. It is at stations in group B largest in the hot weather and smallest in the rains. The same is the case at the majority of stations in group A, more especially Poona and Belgaum.

The epoch of this component is not directly related to that of the corresponding component of the diurnal variation of temperature.

Second Component.—The epoch of maximum of u_2 is fairly constant throughout the year at stations in group B. It is between 8 and 10 A.M. and P.M. and the minima epochs are hence between 2 and 4 A.M. and P.M. The afternoon minimum coincides closely with the epoch of maximum temperature and hence also with the epoch of the first component of the diurnal variation of temperature. Thus on the mean of the ten stations in group B these epochs for the mean day of the year differ by only seventeen minutes. The epoch of the afternoon minimum value of the second component of the aqueous vapour variation is usually slightly later than that of first component of the temperature variation. This is evidently due to the fact that the activity of convective movement in the day hours closely follows the variations of temperature.

There appears to be little or no direct relation between the components u_1 and u_2 of aqueous vapour pressure cloud and temperature. In the case of the two former elements the introduction of the discontinuous element due to convective air movement causes the Besselian resolution to be purely mathematical. Hence for purposes of useful comparison it is necessary to compare not the components but the actual resultant curves. The curves representing the action of evaporation closely approximate in form to those of temperature excepting that the maximum epoch is almost certainly earlier in the former than the latter.

Relative Humidity.—It has not been considered necessary to discuss the data of this element, as it is merely the aqueous vapour pressure in its relation to temperature. The curves of relative humidity are in fact practically inverse to the corresponding temperature curves. As it is an important element of climatic observation, curves are given for reference in Plates XXXII to XXXVII showing the diurnal variation of humidity for the 29 stations at which hourly observations were recorded for each of the following seasons of the year :—

(1) January and February.
(2) March to May.
(3) June and September.
(4) July and August.
(5) October to December,
and also for the whole year.

CHAPTER VI.

Cloud.

The following is a brief summary of the chief meteorological actions which give rise to the formation of cloud :—

(1) Local ascensional movement. All ascending masses of air cool by the loss of their internal energy in the performance of the work of expansion. If the air masses ascend so high that the temperature by cooling falls below the dew point, condensation will commence and give rise to cloud formation. The local ascensional movement may be due to various causes, of which the most important are as follows :—

(*a*) The convective movements which occur during the day hours due to the irregular heating of the earth's surface and the superjacent lower strata of the atmosphere by the sun's thermal action. These movements usually give rise to the formation of clouds of the cumulus type. This action has a well-marked diurnal variation, commencing about 9 or 10 A.M., and reaching its maximum about 3 or 4 P.M. and ceasing about 6 P.M.

(*b*) The ascensional or convective movement which occurs over the central areas of cyclonic storms and in all disturbances giving more or less general rain.

(*c*) The ascensional movement of air across hills which lie athwart the general drift of a massive humid air current. Such currents may be either periodic or non-periodic or irregular. The south-west monsoon currents and the sea breezes on the Bombay, Arakan and other coasts are examples of periodic currents. This forced ascent of the air masses due to this action gives rise to clouds chiefly of the cumulus type. If the strength of this movement has a diurnal variation the accompanying cloud formation will have a similar variation. This is undoubtedly the case to a slight extent in the south-west monsoon drift across the West Ghats and perhaps across the Arakan hills.

(2) Expansional movement on the large scale. There is no doubt that an important part of the diurnal atmospheric movement in India is due to the alternate expansion and contraction of the lower strata arising from their diurnal heating and cooling by contact with the earth's surface and other similar actions. This action is alternating and hence periodic. The character of the movement is partially indicated by the diurnal oscillation of the barometer. It is, however, doubtful whether, except under exceptional circumstances of an almost saturated atmosphere, it gives rise to cloud formation on the large scale. Whenever it does so, the effect will probably occur chiefly about the epoch of the afternoon minimum of the diurnal pressure oscillation. This action occasionally gives rise as a rule to clouds of the stratus type.

(3) The action of atmospheric waves. These waves are formed at the common surface boundary of adjacent air currents of different temperatures and moving with different velocities or in different directions. When one of

the air currents is nearly saturated, condensation may occur as shown by Helmholtz and others in and near the common surface in amounts depending upon the humidity of either wave. All clouds which have an undulating form of the lower surface or clouds which are arranged in long lines or belts with intervals of clear sky are probably due to this action.

(4) The mixture of air masses of different temperature and humidity. This is most effective when cool dry air is injected into hot damp air (*vide* Cleveland Abbe's translation of Bezold's three memoirs "On the Thermodynamics of the Atmosphere."

(5) Cooling of nearly saturated masses of air (*a*) by radiation, (*b*) by conduction, (*c*) by diffusion or (*d*) by motion from hotter to cooler regions.

It may be noted that these causes or actions operate in very different orders of frequency. The most usual causes of the formation of cloud in the dry weather in India are 1*a*, 1*b*, and 2 and to a less extent 1*c* and 3, and in the rains or wet season 1*b*, 1*c*, 2 and perhaps 4 in certain parts of India.

The seasonal variation in the amount of cloud.—This is given by the monthly mean data of the cloud amounts in the memoirs under discussion.

The seasonal distribution of cloud is prominently marked in India. The cloud amount is small over the whole of India with some local exceptions during the dry season and large during the wet season over nearly the whole of the interior as well as in the coast districts. An inspection of the curves giving the annual variation plotted from the cloud data in Plates XXXVIII and XXXIX shows at once the contrast between the cloud conditions of the two periods.

The following gives monthly mean cloud amounts for the 28 stations at which the hourly observations were recorded, determined by two different methods :—

TABLE LXXVI.—*Mean hourly proportion of clouded sky as determined from the two series of observations.*

		January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Year.
LAHORE	Mean from term observations	2·7	3·6	3·0	3·1	2·3	2·2	4·4	3·8	1·9	0·8	0·9	2·7	2·6
	True mean	3·1	3·6	3·0	2·3	2·2	3·0	4·2	3·6	1·8	0·7	1·3	1·9	2·6
KURRACHEE	Mean from term observations	2·0	2·4	2·2	1·4	1·9	3·7	6·7	6·9	3·3	1·0	0·6	1·3	2·8
	True mean	2·6	2·7	2·2	2·0	1·9	4·1	7·0	6·5	3·5	0·5	0·9	1·3	2·9
ROORKEE	Mean from term observations	2·8	4·0	2·9	2·4	2·4	2·9	6·3	6·5	3·4	0·7	0·6	2·1	3·1
	True mean	2·9	3·2	2·5	1·9	1·5	2·9	6·4	6·3	3·3	0·7	0·7	1·5	2·8
AGRA	Mean from term observations	1·7	2·2	2·6	1·6	1·8	3·7	6·1	6·0	3·6	0·9	0·5	1·2	2·7
	True mean	1·9	2·0	2·5	1·2	1·4	3·0	6·5	6·1	3·2	0·9	0·5	1·1	2·5
JAIPUR	Mean from term observations	2·8	2·8	2·6	1·9	2·1	4·2	7·1	7·2	3·3	1·5	1·1	1·9	3·2
	True mean	3·0	2·8	2·7	2·1	1·9	4·4	7·1	7·1	3·9	1·5	1·1	1·7	3·3
LUCKNOW	Mean from term observations	1·5	2·4	2·5	2·1	1·9	4·4	6·9	7·2	4·0	1·3	0·6	1·0	3·0
	True mean	2·1	2·6	2·5	1·4	1·8	3·7	6·9	7·0	4·5	1·7	0·8	1·4	3·0
ALLAHABAD	Mean from term observations	1·6	1·8	1·9	1·6	1·7	5·0	7·4	6·7	4·1	2·0	0·7	0·8	2·9
	True mean	2·0	2·0	2·1	1·3	1·6	4·5	7·5	7·5	5·1	2·0	1·1	1·2	3·2

TABLE LXXVI.—*Mean hourly proportion of clouded sky as determined from the two series of observations*—concld.

		January.	February.	March.	April.	May.	June.	July.	August.	September.	October	November.	December.	Year.
DEESA	Mean from term observations	1·7	1·6	1·5	1·1	1·6	3·5	8·0	8·0	4·3	1·4	0·8	0·9	2·9
	True mean	1·4	1·8	2·0	1·4	1·8	4·0	7·9	7·5	4·8	1·5	1·0	1·3	3·0
PATNA	Mean from term observations	1·8	2·3	2·6	1·8	3·0	6·2	8·2	7·8	6·2	3·3	1·7	2·2	3·9
	Mean	2·6	2·5	2·6	1·8	2·5	6·0	8·2	8·2	6·9	3·3	1·6	1·7	4·0
HAZARIBAGH	Mean from term observations	1·6	1·9	2·0	1·9	3·2	7·4	9·1	8·7	6·9	3·8	2·0	1·8	4·2
	True mean	2·3	2·1	2·0	2·3	3·1	7·2	8·9	8·3	7·4	3·9	2·2	1·9	4·3
DHUBRI	Mean from term observations	1·7	1·9	1·8	3·9	4·8	6·5	7·4	6·7	5·4	2·3	1·2	0·9	3·7
	True mean	1·3	1·3	2·1	3·3	4·7	6·7	7·0	7·1	5·8	2·2	2·2	0·8	3·7
GOALPARA	Mean from term observations	1·9	1·0	2·3	3·5	5·0	6·7	7·6	5·9	5·3	3·0	1·3	1·3	3·7
	True mean	2·6	2·2	2·7	3·9	5·1	7·4	7·2	6·7	6·1	3·7	2·0	2·3	4·3
SIBSAGAR	Mean from term observations	5·2	6·1	6·6	7·7	8·4	9·0	9·2	8·7	8·2	6·1	4·6	4·2	7·0
	True mean	5·4	5·8	6·3	7·0	7·9	8·4	8·5	8·6	8·1	6·7	4·4	4·3	6·8
CALCUTTA	Mean	1·3	1·9	2·5	2·7	4·3	7·1	8·3	8·3	7·3	4·1	2·5	1·7	4·3
CUTTACK	Mean from term observations	1·2	2·0	2·4	2·6	4·3	6·2	6·9	6·5	5·9	3·4	1·9	1·8	3·8
	True mean	1·2	1·6	2·3	2·7	4·2	5·8	7·3	6·5	5·6	3·8	2·3	1·3	3·7
CHITTAGONG	Mean from term observations	1·7	1·6	2·7	3·4	4·8	7·7	7·9	8·1	7·2	4·4	3·3	2·7	4·6
	True mean	1·1	1·8	2·7	3·6	5·0	7·5	7·9	7·7	7·0	4·2	2·8	1·7	4·4
RANGOON	Mean from term observations	1·9	1·1	1·7	2·6	5·6	7·9	8·4	8·2	7·8	4·7	3·7	2·1	4·6
	True mean	1·5	1·4	1·4	2·5	5·0	8·1	8·5	8·1	7·6	5·3	3·7	1·9	4·6
BOMBAY	Mean from term observations	1·4	1·0	1·7	2·1	3·3	6·6	7·3	7·3	6·2	3·9	2·0	1·6	4·7
	Mean	1·4	1·2	1·6	2·2	3·8	7·8	9·1	8·8	7·4	4·1	2·1	1·8	4·3
JUBBULPORE	Mean from term observations	1·8	2·2	2·2	2·2	2·6	6·7	8·2	8·3	4·7	3·0	1·3	1·5	3·7
	True mean	1·6	1·8	1·9	1·8	2·4	6·4	8·4	8·2	6·0	2·1	1·4	1·4	3·6
PACHMARHI	Mean from term observations	1·9	1·9	2·4	2·1	3·1	7·4	9·2	8·8	6·2	4·0	1·3	1·7	4·1
	True mean	1·7	1·6	1·9	2·1	2·7	6·8	8·8	8·6	6·7	2·5	1·8	1·5	3·9
NAGPUR	Mean from term observations	1·5	2·3	2·8	2·9	4·0	7·1	8·7	8·3	6·2	4·0	1·9	2·0	4·3
	True mean	1·7	1·2	2·2	2·3	3·2	7·0	8·7	8·1	6·7	3·2	2·1	1·7	4·0
POONA	Mean from term observations	1·1	1·4	1·4	2·1	2·1	6·7	8·9	6·0	7·5	4·8	2·7	2·3	4·1
	True mean	1·2	0·7	1·7	1·9	1·8	6·4	8·7	8·4	7·0	4·4	2·5	1·7	3·9
BELGAUM	Mean from term observations	0·9	0·6	1·8	2·3	2·9	6·9	9·0	8·0	7·1	4·9	2·7	2·3	4·1
	True mean	1·2	0·9	1·4	2·5	3·1	7·3	8·8	7·9	6·7	5·0	2·0	1·8	4·1
BELLARY	Mean from term observations	1·2	0·6	2·0	3·6	4·1	7·2	8·2	7·3	7·2	5·5	3·5	3·7	4·5
	True mean	1·8	1·2	2·0	3·3	4·8	7·4	8·1	7·7	7·3	6·0	4·0	2·9	4·7
TRICHINOPOLY	Mean from term observations	3·3	2·4	3·0	3·7	4·8	6·1	6·8	7·0	6·2	7·3	6·1	6·4	5·3
	True mean	4·0	2·4	3·0	4·1	5·2	6·7	7·2	7·4	6·8	7·4	6·5	5·7	5·5
MADRAS	Mean	4·0	2·8	2·4	3·0	3·8	6·3	7·2	6·6	6·1	6·0	6·0	5·4	5·0
TRIVANDRUM	Mean from term observations	3·4	3·6	4·1	5·9	6·9	7·8	7·9	7·4	6·7	7·1	6·2	4·8	6·0
	True mean	3·4	3·3	3·9	5·7	6·8	7·8	7·6	7·3	6·5	7·0	6·1	4·5	5·8
LEH	Mean from term observations	5·7	6·9	5·8	6·2	6·0	4·0	4·6	4·8	3·3	3·5	3·1	5·5	4·9
	True mean	6·1	6·3	5·7	5·6	5·4	4·5	4·7	4·6	3·7	3·0	3·3	5·0	4·8
ADEN	Mean from term observations	3·8	3·7	2·8	2·6	2·1	2·1	3·4	2·5	2·0	1·1	2·3	3·0	2·7
	True mean	3·6	3·7	3·1	2·2	1·4	1·4	2·6	2·6	2·3	1·4	1·9	2·9	2·4

The following is a summary of the chief features of the seasonal distribution of cloud in India.

The cloud conditions of Northern and Central India differ to some extent from those of the Peninsula. This is in part due to the difference in the character and period of the south-west monsoon rains in the two areas and in part to the large influence of the neighbouring seas on the meteorology of the Peninsula.

Fine weather in the dry season in the interior of Northern and Central India is generally characterised by clear or very lightly clouded skies, chiefly of the cirrus type.

Rapid changes of the amount and kind of cloud accompany the occasional passage of depressions across Northern India. Hence the mean monthly cloud amounts for the dry season of stations in Northern and Central India in any year are a rough measure of the amount of disturbance during that period. The cloud amount has a well marked diurnal variation in these disturbed periods which does not differ much in general character from that of the light cloud which marks fine weather.

This is shown very clearly by the following mean cloud data for twelve fine days and twelve disturbed days selected at random from the hourly observations recorded on term days at the stations of Lahore, Roorkee and Allahabad :—

Station.		Midnight.	1 hour.	2 hour.	3 hour.	4 hour.	5 hour.	6 hour.	7 hour.	8 hour.	9 hour.	10 hour.	11 hour.	Noon.	13 hour.	14 hour.	15 hour.	16 hour.	17 hour.	18 hour.	19 hour.	20 hour.	21 hour.	22 hour.	23 hour.	Mean of day
Lahore	Mean of 12 fine days	1.5	1.1	1.2	1.4	1.4	1.3	1.4	1.8	1.9	1.7	1.5	1.4	1.6	1.1	1.2	1.6	1.9	1.3	1.4	0.6	0	0.4	0.5	0.8	1.3
	" of 12 disturbed days.	4.5	4.1	4.7	4.2	4.4	4.0	4.4	4.3	4.4	5.1	5.9	6.1	6.7	6.7	7.0	5.9	5.5	5.8	5.5	3.0	4.6	4.4	3.4	3.0	5.0
Roorkee	Mean of 12 fine days	0.6	0.9	0.5	1.0	1.4	1.3	1.4	2.1	1.7	1.6	1.4	1.3	1.5	1.3	1.2	1.5	1.7	2.0	1.6	1.1	1.2	0.7	0.7	0.6	1.3
	" of 12 disturbed days.	6.2	6.2	5.7	5.4	4.7	4.3	4.6	4.7	4.6	5.0	6.2	6.2	6.6	7.0	6.9	6.9	7.4	7.1	6.0	6.8	6.8	6.3	5.8	5.6	6.0
Allahabad	Mean of 12 fine days	0.6	0.2	0	0	0	0	0	0.3	0.4	0.6	0.2	0.0	0.9	1.0	1.4	1.7	1.5	1.6	1.3	0.6	0.5	0.5	0.5	0.6	0.6
	" of 12 disturbed days.	3.2	3.8	3.8	4.3	3.3	3.9	3.8	4.3	4.5	3.8	3.3	4.4	4.6	4.2	4.1	4.2	3.8	4.1	4.2	3.8	3.5	3.1	2.8	3.0	3.8

In the wet or rainy season there is invariably much cloud over the greater part of India, and the absence of cloud indicates abnormal dry weather which, if long continued, intensifies into severe drought. The important variations in this season are hence not the positive but the negative variations. Frequently however in dry seasons the variation is not so much in the extent of cloud but in its depth of which there is at present no measure.

The following gives the more important facts relating to the distribution of cloud in the four seasons of the year, *viz.*:—

The cold-weather period.—(January and February). There is slight to moderate cloud in Southern India during this period and little or no cloud over the Deccan, Konkan, the Central Provinces and Berar. The cloud amount is absolutely least during this period in the Konkan, where skies are practically free from cloud throughout the period. The cloud proportion of the period for Northern India is slight to moderate in amount. It is chiefly due to the dense cloud and overcast skies which accompany the passage of cold-weather storms. The amount is greatest in the Western Himalayas and decreases slightly eastwards to the Assam Hi ıalayas. It is greatest in Northern India in the Punjab and in Assam and is least in the area including Bengal, Bihar and the eastern districts of the North-Western Provinces.

The following table gives mean data for different provinces or areas :—

TABLE LXXVII.

Area.	Average proportion of clouded sky in		
	January.	February.	Period January and February.
Punjab	4·0	3·8	3·9
Sind	2·8	3·1	3·0
Rajputana	2·6	2·6	2·6
North-Western Provinces and Oudh	3·1	3·1	3·1
Bihar	2·0	2·1	2·1
Central India	2·4	2·5	2·5
Chota Nagpur	2·3	2·3	2·3
Bengal	1·6	2·1	1·9
Assam	3·3	3·5	3·4
Central Provinces	1·8	1·7	1·8
Berar	1·7	1·7	1·7
Deccan	1·4	1·2	1·3
Burma	1·9	1·8	1·9
South India	2·7	2·0	2·4
Himalayan Hill Stations, Kashmir	7·3	6·3	6·8
„ „ Punjab and North-Western Provinces	5·1	5·2	5·2
„ „ Sikkim	4·5	4·7	4·6

The hot-weather period (March to May).—The amount of cloud increases during the period in the coast districts due to the increasing intensity of the sea winds. The increase is most marked in Bengal, Assam and Arakan and is least in the Konkan, where skies are almost as free from cloud as in the preceding season. The cloud proportion during the period is practically constant in amount, ranging between 1 and 3, over nearly the whole of the interior of Northern India, including Bihar, Chota Nagpur, the North-Western Provinces, Rajputana, the Punjab, Sind and Baluchistan. It increases to a moderate extent over the interior of the Peninsula and in Bengal, Assam and Burma during the period, due to the increasing influence of the local winds of indraught from the adjacent sea areas.

The following table gives mean data for comparison:—

TABLE LXXVIII.

Area.	Average proportion of clouded sky in			
	March.	April.	May.	Period March to May.
Punjab	3·7	2·0	2·1	2·9
Sind	2·9	2·1	1·6	2·2
Rajputana	2·5	2·1	1·8	2·1
North-Western Provinces and Oudh	2·6	1·9	1·7	2·1
Bihar	2·0	1·4	2·3	1·9
Central India	2·4	2·0	2·5	2·3
Chota Nagpur	2·7	2·8	3·6	3·0
Bengal	3·0	3·4	4·9	3·8

TABLE LXXVIII—*concld.*

AREA.	AVERAGE PROPORTION OF CLOUDED SKY IN			
	March.	April.	May.	Period March to May.
Assam	4·3	5·2	6·4	5·3
Central Provinces	2·0	2·2	2·8	2·3
Berar	2·0	2·2	2·5	2·2
Deccan	1·8	2·6	3·6	2·7
Burma	2·1	3·3	6·3	3·9
South India	2·5	3·7	4·7	3·6
Himalayan Hill Stations, Kashmir	6·0	5·3	4·9	5·4
„ „ Punjab and North-Western Provinces	4·6	4·0	3·7	4·1
„ „ Sikkim	4·4	5·2	6·4	5·3

The rainy season or period (June to September).—After the monsoon rains commence skies are almost continually clouded until the middle of September in the coast districts and over and near the hills in Northern India, and also over a considerable portion of the interior, including the Deccan, the Central Provinces, Chota Nagpur, Bihar and the eastern districts of the North-Western Provinces. Skies are also frequently overcast in North-Western India, but periods of fine weather with clear or lightly clouded skies occur between the intervals of heavy general rain in that area. As the breaks are most frequent and prolonged in Upper India, the mean cloud amount diminishes considerably northwards and westwards over North-Western India. Skies are practically free from cloud in Baluchistan during this period.

The following table gives comparative data:—

TABLE LXXIX.

AREA.	AVERAGE PROPORTION OF CLOUDED SKY IN				
	June.	July.	August.	September.	Period June to September.
Baluchistan	1·1	1·6	1·3	0·5	1·1
Punjab	2·3	3·9	3·6	1·8	2·9
Sind	2·6	4·6	4·5	2·3	3·5
Rajputana	4·3	7·2	7·1	4·1	5·7
North-Western Provinces and Oudh	4·0	7·2	7·1	4·5	5·7
Bihar	5·4	7·3	7·2	6·1	6·5
Central India	5·3	7·7	7·7	5·4	6·5
Chota Nagpur	7·5	9·3	9·0	8·0	8·5
Bengal	7·4	8·2	8·0	7·2	7·7
Assam	7·7	7·9	8·0	7·[illegible]	7·7
Central Provinces	6·1	8·1	7·9	6·1	7·1
Berar	6·5	8·3	8·0	6·6	7·4
Deccan	7·2	8·3	7·8	7·4	7·7
Burma	8·1	8·6	8·4	7·6	8·2
South India	7·1	7·9	7·6	6·9	7·4
Himalayan Hill Stations, Kashmir	4·3	4·6	4·6	3·9	4·4
„ „ Punjab and North-Western Provinces.	5·1	8·0	8·2	5·4	6·7
„ „ Sikkim	7·5	7·9	8·0	7·3	7·7

The retreating south-west monsoon period (October to December).—The humid monsoon currents continue to give much cloud to North-Eastern India in October and to Burma in October and November. The currents are chiefly directed to the Peninsula in November and December, and hence the cloud amount is large in the Coromandel coast districts and Southern India throughout the period, and is moderate in amount in Mysore and the Deccan. Skies are practically free from cloud during the greater part of the period over the whole of North-Western and Central India. Cold weather storms begin to give cloud in December in Upper India. The distribution of cloud is shown fully by the comparative data in the following table:—

TABLE LXXX

Area.	Average proportion of clouded sky in			
	October.	November.	December.	Period October to December.
Punjab	0·9	1·7	2·8	1·8
Sind	0·7	1·3	2·0	1·3
Rajputana	1·6	1·4	1·8	1·6
North-Western Provinces and Oudh	1·2	1·1	1·9	1·4
Bihar	3·0	1·2	1·3	1·8
Central India	2·5	1·4	1·7	1·9
Chota Nagpur	4·4	2·5	2·1	3·0
Bengal	4·4	2·7	2·0	3·0
Assam	4·6	3·0	2·6	3·4
Central Provinces	2·8	1·8	1·7	2·1
Berar	3·5	2·0	2·1	2·5
Deccan	5·4	3·6	2·8	3·9
Burma	5·5	4·0	2·8	4·1
South India	6·1	5·3	4·0	5·1
Himalayan Hill Stations, Kashmir	3·3	3·7	5·5	4·2
" " Punjab and North-Western Provinces	1·8	2·1	3·6	2·5
" " Sikkim	4·9	3·5	3·6	4·0

Annual variation of cloud.—Curves showing the annual variation for the 29 stations in India at which hourly observations were recorded are given in Plates XXXVIII and XXXIX.

The forms of the curves differ slightly for stations in different parts of India. They all agree in showing the large contrast between the cloud amount during the dry season and the wet season. In the Peninsula, Burma and North-Eastern India the annual variation has only one maximum and minimum, the former in July or August, the height of the rains and the latter in November, December, January or February (according to the

period of the termination of the rains). In the area represented by Jubbulpore and Pachmarhi the minimum is in November. In Assam it is in December. In the North Deccan (represented by Nagpur and Poona) it is in January, and in the Konkan, South Deccan and Southern India generally (represented by Bombay, Belgaum, Bellary and Trichinopoly) it is in February, and at Madras in March.

Over the whole of North-Western and Central India, the annual variation consists of two oscillations, the first a feeble one corresponding to the period of the cold weather rains and occasional disturbance, and the second strongly marked and corresponding to the cloudy period of the rainy season. The absolute maxima are in July or August, as in the Peninsula, and the absolute minima in November, the most serene month of the year.

The secondary maximum is in February at the western stations of the Gangetic Plain (*i.e.*, Lahore, Roorkee, Kurrachee and also at Jaipur) and in March at Lucknow, Agra, Allahabad and Patna. There is a very slight indication of this oscillation shown in the cloud curves of Hazaribagh and Dhubri.

Diurnal variation of the amount of cloud.—The diurnal variation of the cloud amount is generally well marked in India. Curves giving the diurnal variation of this element for each month of the year and for the year are plotted for each station at which hourly observations are recorded in volumes V, IX and X of the Indian Meteorological Memoirs. In Plates XLI to XLVI of the present memoir are plotted the curves for the seasons into which the year is divided in India for all the stations at which hourly observations have been recorded. These plates give curves showing the mean diurnal variation for the following periods:—

(1) Cold weather period.
(2) Hot weather period.
(3) Transition months of the rainy season (June and September).
(4) Rainy season proper (July and August).
(5) Retreating south-west monsoon.
(6) The whole year.

An examination of these curves shows that they belong practically, and almost without exception, to five different types. These are as follows:—

(1) Type A. The diurnal variation of this type consists of a single oscillation which has its maximum in the early morning between 6 A.M. and 9 A.M. and its minimum usually in the afternoon.

(2) Type B. This, like the *preceding type, consists of a single oscillation*, but has its maximum in the afternoon usually between 3 P.M. and 5 P.M. and its minimum during the night hours. There is usually little change during the night hours from 8 P.M. to 6 A.M.

(3) Type C appears to be a combination of types A and B. It consists of a double oscillation, the maxima of which occur in the morning between 7 A.M. and 8 A.M. and in the afternoon at about 4 P.M. The amplitude of the afternoon oscillation is usually greater than that of the morning oscillation.

(4) Type D is characterized by a rapid increase of cloud in the early morning and by a similar rapid decrease of cloud in the evening with nearly uniform amount during the whole of the day. It is probably a special form of the

preceding type (C), due to the obliteration of the intermediate minimum between the morning and afternoon maxima, and its most characteristic feature is a prolonged day period lasting for upwards of six hours of large and constant cloud amount.

(5) Type E is characterized by very slight and irregular variation such as occurs in damp cloudy weather during the south-west monsoon at stations in or near the hills or near the sea coast where skies are always more or less heavily clouded.

The mean curves of the first four types for each season of the year will be found plotted in Plate XL. The following is an analysis of the chief features of the diurnal variation of cloud in different parts of India during each of the four seasons of the year:—

The cold weather period—(*vide* curves in Plate XLI and in Plate XLII). The mean cloud amount is less than 2·0 over nearly the whole of Northern and Central India and the Deccan. The only areas in which it exceeds that amount are the Punjab, Rajputana, Upper Sind, the North-Western Provinces West and Oudh, the Himalayan area, Upper Assam and Southern India. These areas are represented by the stations for which data are given below:—

Station	January	February.	Mean
Lahore	3·1	3·6	3·4
Jaipur	3·0	2·8	2·9
Roorkee	2·9	3·2	3·1
Agra	1·9	2·0	2·0
Lucknow	2·1	2·6	2·4
Simla	5·6	5·7	5·7
Leh	6·1	6·3	6·2
Sibsagar	5·4	5·8	5·6
Trichinopoly	4·0	2·4	3·2

The areas of greatest serenity in which the mean cloud amount (the mean of 10 A.M. and 4 P.M. readings) is less than 1·0 are defined by the stations, for which comparative data are given below:—

Station.	January.	February.	Mean.
Ratnagiri	0·6	0·5	0·6
Karwar	0·7	0·5	0·6

Skies are hence most free from cloud at this season of the year in the west coast districts from Bombay to Karwar, or in the Konkan.

Fine weather with clear skies or passing light clouds prevails almost without interruption in the west, north and centre of the Peninsula. Similar weather usually prevails in Northern India, but is interrupted at intervals by cold weather storms which give much cloud. The period is usually very cloudy throughout in the Western Himalayas and

probably to a slightly less extent in the Central and Eastern Himalayas. The diurnal variation is feebly exhibited in Northern and Central India during the period. It is, on the other hand, well marked and pronounced in the Peninsula, the hottest area in India during this period. Convective movement is hence fairly vigorous in that area during the day hours. There is also a moderate indraught from the adjacent seas (more especially from the Bay of Bengal). This indraught is continuous and seasonal in the eastern half of the Peninsula. In the west coast districts where the land and sea breezes alternate steadily at this time it is a diurnal feature, the sea breezes obtaining during the day hours and hence supplementing the action of the convective movements over the interior.

The diurnal variations in different parts of India during this period may be arranged under three of the five types stated in pages 167-168.

Type A.—The diurnal variation is of the type A at Sibsagar and Goalpara. The following gives mean hourly variation data for these Assam stations :—

TABLE LXXXI.

HOUR.	Variation from mean of day.	HOUR.	Variation from mean of day.
Midnight . .	−0·17	Noon . .	+0·04
1 . . .	−0·08	13 . . .	+0·12
2 . . .	−0·14	14 . . .	+0·15
3 . . .	−0·03	15 . . .	+0·01
4 . . .	−0·07	16 . . .	−0·07
5 . . .	−0·01	17 . . .	+0·08
6 . . .	+0·14	18 . . .	+0·03
7 . . .	+0·30	19 . . .	−0·39
8 . . .	+0·45	20 . . .	−0·16
9 . . .	+0·19	21 . . .	−0·12
10 . . .	+0·18	22 . . .	−0·25
11 . . .	+0·02	23 . . .	−0·18
		Mean of day .	3·54

The data for these two stations are plotted in Fig. 1, Plate XL.

The amplitude of the diurnal variation at the Assam stations, Sibsagar and Goalpara is very small, much smaller in amount than the amplitudes of the variation for the remaining seasons of the year at these stations. As is usual when the amplitude of the variation is small, the curve representing the variation is very irregular.

The epoch of the maximum of cloud is 8 A.M. at both stations. The minimum occurs at 4 P.M. at Sibsagar and 7 P.M. at Goalpara.

It should, however, be noted that there is much mist and fog at these stations in January and February and it is probable that the observers did not carefully distinguish between

fog and cloud. On the other hand, the law of variation indicated by the observations is probably real as it is exhibited by these stations in the remaining seasons of the year when there is little or no fog.

The diurnal variation of cloud at Aden is very remarkable in this period. The mean cloud amount is 3·8. The diurnal variation consists of a single oscillation, the maximum of which (6·8) occurs at 9 A.M. and the minimum (1·6) at 4 P.M. The range of variation is hence extraordinarily large.

It may be noted that this type of the diurnal variation of cloud is of comparatively rare occurrence and in India is almost restricted to the Assam stations where it obtains throughout the whole year. Its character is such as to at once establish that the pre-monsoon rainfall of the months of March, April and May in Assam is not (as maintained by Blanford) due to local evaporation. The rainfall at that season chiefly occurs in the afternoon and evening and accompanies thunderstorms and hailstorms. If this rainfall and the cloud distribution of the period were due to the same cause (local evaporation), it is evident both should be at a maximum in the afternoon hours.

The peculiar cloud and other meteorological features of the Assam stations are largely the product of its geographical features and conditions. The Assam Valley is upwards of 400 miles long and from 25 miles to 100 miles in breadth, the width increasing westwards towards its mouth. Of this width, the Brahmaputra with the grassy jungle on its banks incapable of cultivation occupies a space of from 6 miles to 20 miles in width. The valley itself is perfectly level except where offshoots of the Assam hills come down to the river as at Gauhati and is only about 400 feet above the sea level at Sadiya, near its eastern extremity, and 120 feet above at Dhubri, its western extremity.

The slope of the level is hence barely 9 inches per mile. The air movement in the valley is light in all seasons and is practically nil at night. It is completely shut in on the north by the lofty Himalayas with peaks rising to heights ranging from 20,000 to 25,000 feet. It is partially cut off from the air movement over Bengal by the Lower Assam hills to the south.

It has a considerable range of temperature, and a high humidity due partly to the absence of air movement and partly to the large amount of local evaporation. Hence during a large part of the dry season of clear skies it is very subject to fogs which form in the early morning about 4 A.M. or 5 A.M. and are frequently not dissipated until 9 A.M. or 10 A.M. As the surface is densely covered with jungle there is little convective movement.

The formation of cloud is hence almost solely due to the processes of conduction and radiation and only to a very slight extent to convective movement.

In the Assam hills there is much cloud after November in the dry season due to the prevalence of a return air current from south-west. This is apparently continued across the Assam Valley and gives rise to much cloud in the Assam Himalayas. It is probable that this damp current blowing across the valley at a moderate elevation in conjunction with the descending and ascending movements between the plains and hills contributes to the formation of cloud.

Type B.—The diurnal variation belongs to type B at fifteen stations. The variation of this type, it may be added, consists of a single oscillation, the epoch of the maximum of which is in the afternoon about 4 P.M.

The stations of which the diurnal variation of cloud during the cold weather belongs to this type are arranged in two groups. The first group consists of nine stations in the interior of Northern India named below:—

Allahabad,	Agra,
Patna,	Roorkee,
Dhubri,	Lucknow,
Hazaribagh,	Lahore,
	Jaipur,

and perhaps Cuttack.

A curve representing the mean diurnal variation of cloud at these stations during this season will be found in Fig. 2, Plate XL. At these stations the amplitude of the diurnal variation is small to moderate in amount, and the variation as deduced from the term observations is characterized by much irregularity.

The second group of stations include six stations in the interior of the Peninsula. The amplitude of the variation at these stations is moderate to considerable in amount and the variation fairly regular. The following gives a list of this group of stations:—

Jubbulpore.	Poona.
Pachmarhi.	Bellary.
Nagpur.	Belgaum.

The mean diurnal variation of cloud at these stations is represented by Fig. 3, Plate XL.

The chief features of the diurnal variation of cloud at the first of these two groups of stations are—

(1) Small to moderate amplitude of variation.

(2) The variation has only one maximum and minimum.

(3) The minimum occurs during the night hours, on the mean of all stations about 11 P.M.

(4) The maximum occurs at four of the stations at 4 P.M. and on the mean of all at 4-30 P.M. very approximately.

(5) The mean cloud amount for the period at the nine stations is 2·3 and the mean amplitude of variation 1·0. The amplitude varies very slightly from station to station and increases on the whole from the eastern to the western stations.

(6) There is a slight but well marked increase of cloud between 4 and 6 A.M.

The chief features of the diurnal variation of the second group of stations are as follows:—

(1) The amplitude of the variation is moderate in amount (from 20 to 50 per cent. of the actual mean cloud amount of the day.) It is on the average of all stations 1·4 and hence considerably larger for this group than for the first group. The mean amount of cloud during this period at these stations is 1·4, ranging from 0·8 at Belgaum to 2·0 at Jubbulpore.

(2) The minimum of the single oscillation occurs between 2 A.M. and 4 A.M. and on the average of the six stations at 3 A.M.

(3) The epoch of the maximum ranges between 3 P.M. and 5 P.M., and on the average of all stations is at 4 P.M.

(4) The evening fall is rapid, occurring chiefly between 4 P.M. 8 and P.M., after which the amount of cloud is nearly constant during the night.

(5) It is noteworthy that there is a well marked increase of cloud between 5 A.M. and 7 A.M. which is very clearly shown in the mean curves, Figs. 2 and 3, Plate XL.

The character of the variation shows that it is almost solely due to convective movement in both groups of stations. The greatest variation occurs in the Deccan, where the convective movement is most vigorous during the cold-weather period. It is also noteworthy that the maximum of cloud is almost coincident with the minimum of air pressure and that it is very shortly after the epoch of maximum temperature and of greatest convective movement in the lowest air strata. That it is almost solely due to convective action, perhaps slightly supplemented by the day indraught due to sea breezes in the Peninsula, is further confirmed by the following features :—

(1) Uniformity of amount during the greater part of the night.

(2) The amplitude is roughly proportional to the amount of convective action (as measured by ground surface minus air temperature).

The following gives the mean data of the diurnal variation for these two groups of stations (plotted in Figs. 2 and 3, Plate XL) :—

TABLE LXXXII.

Hour.	Variation from mean of day. 1st Group.	Variation from mean of day. 2nd Group.	Hour.	Variation from mean of day. 1st Group.	Variation from mean of day. 2nd Group.
Midnight	−0·40	−0·46	Noon	+0·30	+0·35
1	−0·35	−0·47	13	+0·39	+0·50
2	−0·31	−0·54	14	+0·47	+0·67
3	−0·40	−0·54	15	+0·51	+0·79
4	−0·34	−0·53	16	+0·56	+0·79
5	−0·36	−0·39	17	+0·47	+0·75
6	−0·08	−0·15	18	+0·34	+0·47
7	+0·12	+0·14	19	−0·08	−0·25
8	+0·15	+0·11	20	−0·27	−0·46
9	+0·13	+0·09	21	−0·36	−0·45
10	+0·15	+0·15	22	−0·49	−0·46
11	+0·18	+0·13	23	−0·50	−0·53
			Mean of day	2·29	1·44

In the previous two groups of stations (Type B) it is interesting to note that there is a sharp increase of cloud in the early morning from about 4 A.M. to 6 A.M. or 7 A.M., similar in character to that at the Assam stations but small in amount. A reference to

the curves of the stations composing these two groups shows that it is exhibited by the following stations as shown below:—

Roorkee	slightly,	Poona	slightly,
Jaipur	"	Belgaum	"
Lahore	"	Bellary	very slightly,
Cuttuck	"	Patna	"
Jubbulpore	"	Hazaribagh	"
Pachmarhi	"	Dhubri	markedly,
Nagpur	"		

that is, by practically all the stations of the two groups.

The action is marked—

(1) near the sea (*vide* the Rangoon curve, Fig. 3, Plate XLII), and

(2) near the hills, as shown by the curves for Dhubri and Roorkee.

Type D.—The diurnal variation of cloud is of the Type D at the following stations:—

Deesa,	Trichinopoly,
Kurrachee,	Leh, and perhaps
Chittagong,	Rangoon.

All these stations are, with the exception of Leh, on or near the sea coast. At these stations we have evidently an effect due to proximity to the sea, and a convective effect, both marked. The former effect is evidently similar to the morning action in the Assam Valley, *i.e.*, a tendency to the formation of cloud in the early morning at the coolest time of the night, very slight in amount generally in the dry interior, but locally marked in certain cases.

The following gives the mean data of the diurnal variation for the above named group of stations (plotted in Fig. 4, Plate XL).

TABLE LXXXIII.

Hour.	Variation from mean of day.	Hour.	Variation from mean of day.
Midnight	−0·33	Noon	+0·66
1	−0·72	13	+0·67
2	−0·74	14	+0·69
3	−0·59	15	+0·66
4	−0·45	16	+0·65
5	−0·28	17	+0·60
6	−0·24	18	+0·29
7	+0·58	19	−0·11
8	+0·49	20	−0·72
9	+0·46	21	−0·82
10	+0·67	22	−0·85
11	+0·54	23	−0·86
		Mean of day	2·91

In the case of Leh, the diurnal variation of cloud follows the same law as the diurnal variation of cloud over the snows as seen from Simla in fine weather (*vide* Indian Meteorological Memoirs, Volume VI, page 357.)

It is a minimum in the morning and gradually increases in amount until the warmest time of the day and then decreases, and is evidently due to evaporation from the snows.

The hot-weather period.—This period is usually characterized by high temperature, large diurnal range of temperature and great dryness of the air over nearly the whole of the interior of India. Convective movements are hence very vigorous, due to the intensity of the thermal actions in the interior of India and to the great differences of temperature between the earth's surface and the air strata immediately overlying it.

Local sea winds usually commence in March on the Bengal, Sind and Kathiawar coasts, and intensify rapidly with the increasing severity of the hot weather conditions. Convective movements, due to the forced ascent of these local sea winds by the Assam, Arakan and other hills, give much cloud in Burma and North-Eastern India. A similar moderate to considerable increase of cloud due to similar causes occurs in Southern India. The sea winds on the west coast fail to give rise to much increase of cloud in the coast districts. There is, on the other hand, a large increase in the West Ghâts and the western half of the Vindya and Satpura ranges (as shown by the data for Belgaum, Poona, Nagpur, Pachmarhi and Jubbulpore).

Over the remainder of India including nearly the whole of North-Western and Central India, the Deccan and West Coast the amount of cloud is small in amount, though slightly larger than in the preceding season.

The chief meteorological actions determining the diurnal variation of cloud in this season are—

(1) The large convective movements during the day hours in the interior.

(2) The varying indraught by day and night into the interior of India from the adjacent seas across the Burma, Bengal, Madras and North Bombay coasts.

The remaining actions enumerated in pages 160—1 are probably less influential during this period than during the remaining seasons of the year. The most important is (5), *viz*, cooling by conduction and radiation in the early morning hours.

As some of these actions, more especially convective action, are much more vigorous and energetic in the hot than the cold weather, the diurnal variation at the majority of stations is similar in character to that of the cold weather, but the amplitude of the variation is much larger in amount.

The cold and hot weather periods form the two divisions of the dry season and are characterized by similar meteorological conditions and actions.

The following gives a brief analysis of the character of the diurnal variation of cloud in the hot weather at the 29 stations under discussion, arranged according to the types (A to D) to which they belong. The mean data are plotted in Figs. 5 to 10, Plate XL.

Type A.—To this type belongs the diurnal variation at Sibsagar, Goalpara and Dhubri (and hence probably at all stations in the Assam Valley) and also at Chittagong and Aden. The diurnal variation at these stations is well marked. It consists of a single oscillation, the maximum of which at the Assam stations occurs at about 8 A.M. The variation from 2 P.M. to midnight is small in amount and irregular. The diurnal

variation at Aden belongs to the same type, but is of considerably greater amplitude than at the Assam stations. The amount of cloud at that station increases rapidly from 1·9 at 2 A.M. to 7 A.M., when it attains its mean maximum value of 4·6. It thence decreases to 1·5 at 3 P.M., and is approximately constant in amount until 2 A.M. The variation at Chittagong is similar but less regular. The maximum at that station is at 10 A.M.

The following gives mean data of the diurnal variation for the Assam Valley stations plotted in Fig. 5, Plate XI :—

TABLE LXXXIV.

Hour.	Variation from mean of day.	Hour.	Variation from mean of day.
Midnight . . .	−0·21	Noon	0
1 . . .	+0·06	13	−0·24
2 . . .	+0·01	14	−0·53
3 . . .	+0·08	15	−0·48
4 . . .	+0·29	16	−0·45
5 . . .	+0·42	17	−0·35
6 . . .	+0·63	18	−0·21
7 . . .	+0·79	19	−0·45
8 . . .	+0·98	20	−0·73
9 . . .	+0·89	21	−0·56
10 . . .	+0·52	22	−0·42
11 . . .	+0·28	23	−0·44
		Mean of day . .	4·89

The causes of this type of variation in the hot weather are similar to those in the cold weather (*vide* pages 169—170).

Type B.—The stations of which the diurnal variation of cloud in this season is of this type are arranged in two groups. The first group includes Jaipur and Hazaribagh. At these two stations the amount of cloud is practically constant on the mean day of the period from 8 P.M. to 11 A.M. and increases to the maximum of the day at 3 P.M. decreasing again until 8 P.M. The only important feature is the oscillatory change from 11 A.M. to 8 P.M., reaching its maximum at 3 P.M.

There is a tendency to slight increase of cloud in the early morning. It gives rise to a slight oscillation between 4 A.M. and 8 A.M., the maximum of which is at 6 A.M. It is more marked at Hazaribagh than Jaipur.

The second group includes the Peninsular stations of Jubbulpore, Pachmarhi, Nagpur, Bellary, Belgaum, Poona and Trivandrum.

At these stations the afternoon oscillation is large and well marked. There is at these stations, as at the previous group of stations, a tendency to a slight increase of cloud in the early morning. It is barely traceable in the Jubbulpore, Trivandrum and Nagpur curves, but is distinctly shown in the curves for Belgaum, Bellary and Trichinopoly. *This feeble morning oscillation extends from 4 A.M. to 9 A.M. and has its maximum at 6 A.M.*

The following gives data for the diurnal variation of the two groups of stations for comparison (*vide* Figs. 6 and 7, Plate XL) .—

TABLE LXXXV.

Hour	Variation from mean of day. 1st Group	Variation from mean of day. 2nd Group.	Hour.	Variation from mean of day. 1st Group.	Variation from mean of day. 2nd Group
Midnight	−0·47	−0·40	Noon	+0·19	−0·12
1	−0·47	−0·42	13	+0·67	+0·26
2	−0·47	−0·44	14	+1·05	+0·87
3	−0·48	−0·49	15	+1·22	+1·21
4	−0·53	−0·52	16	+1·15	+1·43
5	−0·22	−0·36	17	+0·85	+1·24
6	−0·09	−0·15	18	+0·61	+0·89
7	−0·27	−0·26	19	+0·15	+0·31
8	−0·29	−0·43	20	−0·25	−0·21
9	−0·24	−0·55	21	−0·53	−0·29
10	−0·35	−0·49	22	−0·52	−0·38
11	−0·25	−0·44	23	−0·51	−0·40
			Mean of day	2·30	3·03

The most interesting of the two varieties of this type is that of the Peninsular stations. The following gives the chief features of the diurnal variation of cloud at these stations during this period :—

(1) A day oscillation of large amplitude, the maximum amount occurring at 4 P.M., shortly after the period of highest temperature and greatest convective activity in the lowest air strata. At Belgaum the maximum is at 2 P.M. but the cloud amount is almost constant during the next two hours.

(2) The amplitude of this day oscillation increases from March to May and is very large in the latte rmonth at the stations in the Central Provinces and in April at Bellary. It averages 4·2 in May at Nagpur (the mean cloud amount for the month being only 4·0) and 4·1 in April at Bellary (the mean cloud amount for the month being 3·6).

(3) The night and early morning oscillation is of small amplitude and varies considerably in its period and amount at different stations. The maximum varies slightly in its epoch, and occurs on the average of all stations at 6 A.M.

(4) The minima values of the cloud amount are at midnight and at 9·30 A.M.

(5) The variations are small during the night hours from 8 P.M. to 4 A.M.

The variation at Jaipur and Hazaribagh is chiefly due to convective action. In the Peninsula it is due to convective action and to varying indraught from the neighbouring seas. At Poona and Belgaum the air movement shows a strong land influence during the night hours and a strong sea influence during the day hours. The amplitude of the diurnal variation is hence very large at these stations during this period, consisting of a double oscillation each of moderate and comparable amplitudes.

Type C.—The stations at which the diurnal variation is of this type may be arranged in two groups according to the relative magnitudes of the two oscillatory variations of which it consists. The first group in which the morning oscillation is relatively the most important includes Kurrachee and Cuttack.

The second group includes certain stations in Northern India for which the amplitudes of the two oscillations are not large and are approximately equal in amount. These stations are—

Roorkee.	Agra.
Lucknow.	Allahabad.
Patna.	Deesa.

The following gives mean data for the diurnal variation of the two groups of stations for comparison. They are plotted in Figs. 8 and 9, Plate XL:—

TABLE LXXXVI.

Hour.	Variation from mean value. 1st Group.	Variation from mean value. 2nd Group.	Hour.	Variation from mean value. 1st Group.	Variation from mean value. 2nd Group.
Midnight	[illegible]	[illegible]	Noon	[illegible]	[illegible]
1	[illegible]	[illegible]	13	[illegible]	[illegible]
2	[illegible]	[illegible]	14	[illegible]	[illegible]
3	[illegible]	[illegible]	15	[illegible]	[illegible]
4	[illegible]	[illegible]	16	[illegible]	[illegible]
5	[illegible]	[illegible]	17	[illegible]	[illegible]
6	[illegible]	[illegible]	18	[illegible]	[illegible]
7	[illegible]	[illegible]	19	[illegible]	[illegible]
8	[illegible]	[illegible]	20	[illegible]	[illegible]
9	[illegible]	[illegible]	21	[illegible]	[illegible]
10	[illegible]	[illegible]	22	[illegible]	[illegible]
11	[illegible]	[illegible]	23	[illegible]	[illegible]
			Mean of day	[illegible]	[illegible]

The maxima epochs at stations of the first group are at 7 A.M. and 4 P.M. and the minima at about 11 A.M. and midnight.

Type D.—The diurnal variation of cloud during the season is of the type D at Rangoon, Trichinopoly, Calcutta and Lahore. The hourly variations for the mean of these stations (excepting Calcutta) are given below:—

TABLE LXXXVII.

Hour	Variation from mean of day.	Hour.	Variation from mean of day
Midnight	−1·03	Noon	+0·59
1	−1·08	13	+0·75
2	−0·95	14	+0·85
3	−0·91	15	+0·98
4	−0·80	16	+1·06
5	−0·22	17	+0·92
6	+0·35	18	+0·83
7	+0·53	19	−0·24
8	+0·48	20	−0·76
9	+0·49	21	−0·84
10	+0·58	22	−0·96
11	+0·31	23	−0·96
		Mean of day	3·31

The cloud amount at these stations is nearly constant from 8 P.M. to 4 A.M. It thence rises very rapidly until 6 A.M. and is nearly constant until noon. It thence rises again slightly to the maximum of the day at 4 P.M., falls very slightly until 6 P.M and thence very rapidly until 8 P M.

The rainy season.—In this season the meteorological conditions are favourable to cloud formation over nearly the whole extent of India. A humid current of great volume and moderate intensity flows from the Indian Ocean across the Arabian sea and Bay of Bengal into India. This current is of considerable depth, probably exceeding 13,000 or 14,000 feet, over the greater part of India during the period. It is also highly charged with aqueous vapour, and hence the very feeblest disturbance gives rise to condensation, formation of cloud and rain. In the neighbourhood of the coasts and the mountains of Western, Northern and Central India skies are almost continuously overcast during the greater part of the period. The mean cloud amount decreases from these districts westwards and northwards towards the drier districts of the interior, including Baluchistan, Sind, West Rajputana and the West Punjab.

The cloud data show that skies are heavily clouded throughout the whole season in the coast and hill districts and also in the North Deccan. In the interior of Northern

India, including the Gangetic Plain, the East Punjab, Central India and East Rajputana, the amount of cloud is slightly less than in the coast districts in the months of July and August, most fully representative of the period.

The amount of cloud decreases rapidly westwards and northwards in West Rajputana, the West Punjab and Sind, and is small in Baluchistan. In these areas periods of fine weather alternate with short occasional intervals of disturbed weather with cloud and rain, due either to the march of cyclonic storms from the Bay into Upper India or to the prevalence of a very strong advance of monsoon winds to the extreme limits of the monsoon region in India.

It may also be noted that the monsoon currents are usually not fully established over the whole of India until nearly the end of June and that they commence to withdraw from North-Western India in September. The months of July and August are hence most fully representative of the rainy season. The months of June and September are transitional periods in North-Western India and the cloud conditions of these months are more or less combinations of rainy season conditions with those of the preceding hot weather season and subsequent retreating south-west monsoon season.

The diurnal range of temperature is considerable during this period in the drier districts of the Deccan and over a large area in North-Western India including Baluchistan, Upper Sind, Rajputana, and the West and Central Punjab. The indraught into India from the neighbouring seas has a corresponding fluctuation. In other words, the air movement over the interior of India is, as a rule, feebler by night than by day and the increased air movement attains its maximum at about 2 P.M. or the period of maximum day temperature. This increased horizontal activity accompaines increased vertica or convective movement. These actions hence give rise to a corresponding diurnal variation in the amount of cloud, the chief causes of which may be summed up as follows:—

(1) Diurnal variation of the intensity of indraught of the humid currents into India, in large part due to the diurnal variation of temperature in the interior.

(2) Large convective action in the drier districts of the interior.

(3) Actions preceding and accompanying general rainfall, more especially during the march of cyclonic storms.

Type A—The diurnal variation of cloud amount during this season belongs to this type (a single oscillation, the maximum of which is in the morning) at the following stations:—

Goalpara.	Kurrachee.
Sibsagar.	Aden.
Dhubri.	

At the Assam stations the variation is of moderate amplitude, attaining its maximum value at 6 A.M. and minimum at 8 P.M. The following gives mean variation data for the three Assam stations (Goalpara, Dhubri and Sibsagar) where the law of variation is of the same type throughout the whole year and also for the remaining stations of the group, *viz.*, Aden and Kurrachee. The data for the Assam stations are plotted in Fig. 11, Plate XL.

TABLE LXXXVIII.

Hour.	Variation from mean of day at Assam stations		Variation from mean of day (Kurachee and Aden)	
	Amount.	Variation.	Amount.	Variation.
Midnight	7·41	−0·19	5·38	+0·49
1	7·91	+0·31	5·65	+0·77
2	8·11	+0·51	5·63	+0·74
3	8·34	+0·74	5·80	+0·92
4	8·28	+0·68	5·50	+0·62
5	8·39	+0·79	5·45	+0·57
6	8·67	+1·07	5·38	+0·49
7	8·39	+0·79	5·15	+0·27
8	8·24	+0·64	4·95	+0·07
9	7·91	+0·31	4·95	+0·07
10	7·98	+0·38	4·90	+0·02
11	7·57	−0·03	4·68	−0·21
Noon	7·36	−0·24	4·20	−0·69
13	7·46	−0·14	3·93	−0·96
14	7·34	−0·26	3·93	−0·96
15	7·35	−0·25	4·08	−0·81
16	7·44	−0·16	4·23	−0·66
17	7·26	−0·34	4·33	−0·56
18	7·25	−0·35	4·45	−0·44
19	6·90	−0·70	4·68	−0·21
20	6·47	−1·13	4·65	−0·24
21	6·50	−1·10	4·70	−0·19
22	6·85	−0·75	5·30	+0·42
23	7·00	−0·60	5·38	+0·49
Mean of day	...	7·60	...	4·89

The diurnal variation of cloud in this season at Aden is large in amount. It i largest during the night hours from 8 P.M. to 6 A.M. when it is practically unchange in amount, averaging 3·7. It decreases rapidly from 6 A.M. to 1 P.M. when it is only 1· (the minimum of the day). The variation at this station is apparently a result of th rapid heating of the rocky hills during the day hours and their equally rapid coolin during the night hours, and is hence due to special local causes or actions.

Type B.—The diurnal variation of cloud is of this type at eight stations, which may be subdivided into two groups. At the stations in the first series the variation is moderate to large in amplitude, whilst at those in the second series it is slight :—

First Group.	Second Group.
Leh.	Jubbulpore.
Cuttack.	Nagpur.
Bellary.	Poona.
Agra.	Pachmarhi.

The following gives mean hourly variation data for the two groups of stations (excluding Leh) plotted in Figs. 12 and 13, Plate XL :—

TABLE LXXXIX.

Hour.	Variation from mean of day. 1st Group.	Variation from mean of day. 2nd Group.	Hour.	Variation from mean of day. 1st Group.	Variation from mean of day. 2nd Group.
Midnight	−0·65	−0·20	Noon	+0·69	+0·25
1	−0·64	−0·24	13	+0·76	+0·31
2	−0·59	−0·25	14	+0·86	+0·15
3	−0·63	−0·24	15	+0·89	+0·10
4	−0·68	−0·19	16	+0·89	+0·07
5	−0·51	−0·17	17	+0·71	+0·14
6	−0·19	0	18	+0·49	+0·19
7	−0·03	+0·04	19	+0·02	+0·10
8	+0·01	+0·07	20	−0·39	−0·12
9	+0·04	+0·09	21	−0·53	−0·18
10	+0·31	+0·32	22	−0·66	−0·22
11	+0·49	+0·25	23	−0·71	−0·27
			Mean of day	6·84	8·54

The epochs of the maximum and minimum values at the first group of stations are at 3 P.M. and 11 P.M. The average cloud amount differs very little at the Peninsular stations in July and August, ranging between 7·8 at Bellary and 8·5 at Belgaum and Nagpur, and 9·0 at Pachmarhi. It is considerably less at Agra (6·0) and Cuttack (6·7). The amplitude of the oscillation on the whole is largest at the stations at which the cloud amount is least, *e.g.*, Cuttack (2·0), and is very small in the case of the stations in the Central Provinces and North Bombay, *e.g.*, Nagpur (0·8), Jubbulpore (0·6) and Poona (0·9).

Type C.—The diurnal variation belongs to this type at Trichinopoly. The maxima occur at 7 A.M. and 7 P.M. and the minima at noon and 4 A.M. The morning oscillation is slightly larger in amplitude than the afternoon. Both are, however, well marked, and the curve for Trichinopoly (Fig. 14, Plate XL) is a good example of this type of variation.

The variation is very small at Deesa and Trivandrum, but belongs to the same type.

TABLE XC.

Hour.	Variation from mean of day.		Hour.	Variation from mean of day.	
	Mean of Trichinopoly.	Mean of Deesa and Trivandrum.		Mean of Trichinopoly.	Mean of Deesa and Trivandrum.
Midnight	−0·11	−0·31	Noon	−0·61	+0·15
1	−0·11	−0·26	13	−0·56	−0·03
2	−0·21	−0·24	14	−0·41	+0·04
3	+0·14	−0·31	15	−0·31	+0·09
4	−0·21	−0·18	16	−0·21	+0·33
5	−0·01	−0·02	17	+0·09	+0·28
6	+0·59	+0·15	18	+0·19	+0·08
7	+0·69	+0·28	19	+0·24	−0·20
8	+0·[illegible]	+0·38	20	+0·04	−0·50
9	+0·34	+0·53	21	−0·01	−0·65
10	+0·19	+0·49	22	−0·06	−0·61
11	−0·21	+0·36	23	−0·16	−0·38
			Mean of day	6·86	7·82

Type D.—The diurnal variation belongs to this type at the following stations:—

Jaipur.	Allahabad.
Lahore.	Hazaribagh.
Belgaum.	Lucknow.

Rangoon.

At all these stations there is a considerable increase of cloud in the early morning hours from 4 A.M. to 6 A.M. or 7 A.M. From that hour until 6 P.M. the amount of cloud varies very slightly. A rapid fall occurs between 6 P.M. and 8 P.M. or 9 P.M., after which the cloud amount is fairly constant until the early morning. The amounts of the early morning and evening changes differ considerably, being on the whole largest at stations most distant from the sea (represented by Lahore and Lucknow). At Roorkee, immediately under the hills, the variation is much less—showing that position relative to the

hills as well as to the sea exercises an important influence. The following table gives mean variation data for the group of stations :—

TABLE XCI.

Hour.	Variation from mean of day.	Hour.	Variation from mean of day.
Midnight	−0·74	Noon	+0·58
1	−0·83	13	+0·58
2	−0·66	14	+0·64
3	−0·56	15	+0·61
4	−0·44	16	+0·55
5	+0·08	17	+0·40
6	+0·35	18	+0·29
7	+0·31	19	−0·12
8	+0·36	20	−0·66
9	+0·48	21	−0·83
10	+0·58	22	−0·75
11	+0·60	23	−0·88
		Mean of day	7·30

The retreating south-west monsoon period.—This is a transitional period. The humid currents of the south-west monsoon gradually withdraw from the Indian area, and are replaced by light land winds which gradually develop into the winds or air movement of the north-east monsoon. This change commences in Upper India in September, in the Lower Gangetic Plain and Central India in October, in Burma in October or November, in the Deccan and North Madras in November, and is generally completed in South India, Ceylon and the south of the Bay in December. These changes give rise to corresponding variations in the amount of cloud which alters from that characteristic of the rainy season to that of the dry season in Northern and Central India.

The following mean cloud data illustrate fully this change and its progress southwards and eastwards :—

TABLE XCII.

Area.	Average proportion of clouded sky in				
	September.	October.	November.	December.	Period September to December.
Punjab	1·8	0·9	1·7	2·8	1·8
Sind	2·3	0·7	1·3	2·0	1·6
Rajputana	4·1	1·6	1·4	1·8	2·2

TABLE XCII—*concld.*

Area	Average proportion of clouded sky in				
	September.	October.	November.	December.	Period September to December.
North-Western Provinces and Oudh	4·5	1·2	1·1	1·9	2·2
Bihar	6·1	3·0	1·2	1·3	2·9
Central India	5·4	2·5	1·4	1·7	2·8
Chota Nagpur	8·0	4·4	2·5	2·1	4·3
Bengal	7·3	4·3	2·6	2·0	4·1
Central Provinces	6·1	2·8	1·8	1·7	3·1
Berar	6·6	3·5	2·0	2·1	3·6
Deccan	7·4	5·4	3·6	2·8	4·8
Burma	7·6	5·5	4·0	2·8	5·0
South India	6·9	6·1	5·3	4·0	5·6
Himalayan Hill Stations, Kashmir	3·9	3·3	3·7	5·5	4·1
„ „ Punjab and North-Western Provinces	5·4	1·8	2·1	3·6	3·2
„ „ Sikkim	7·3	4·9	3·5	3·6	4·8

The cloud amount steadily decreases from September to December in Burma, Bengal and the Peninsula and is small over the whole area in December. It is throughout small in North-Western and Central India, but increases slightly in November and December, due to the occasional passage of early cold-weather depressions across these areas.

Type A.—The diurnal variation of the cloud amount in this season belongs to Type A., at the Assam stations and Aden. The representative curve for these stations given in Figure 16, Plate XL, has a single oscillation, the maximum of which is in the morning at 9 A.M.

The variation is of moderate amplitude at Goalpara and Sibsagar and the representative curve for this season is similar to those of the preceding seasons of the year. The maximum at Goalpara is at 8 A.M., at Aden at 9 A.M. and at Sibsagar at 10 A.M. The minimum is at 5 P.M. at Aden and at about 8 P.M. at Sibsagar and Goalpara. The amplitude of the variation is about 1·2 at Sibsagar, 1·5 at Goalpara and 2·5 at Aden (the mean cloud amount being 3·1).

The increase of cloud in the early morning hours at the Assam stations appears to be due, as already explained, to the following actions:—large evaporation and moderate convective action.

The following gives mean data of the diurnal variation of cloud for this group of stations (plotted in Fig. 16, Plate XL):—

TABLE XCIII.

Hour.	Variation from mean of day.	Hour.	Variation from mean of day.
Midnight	−0·35	Noon	+0·27
1	−0·32	13	+0·16
2	−0·23	14	−0·13
3	−0·17	15	−0·35
4	−0·12	16	−0·31
5	+0·04	17	−0·32
6	+0·41	18	−0·41
7	+0·57	19	−0·60
8	+0·87	20	−0·51
9	+0·61	21	−0·35
10	+0·52	22	−0·23
11	[illegible]	23	−0·13
		Mean of day	3·5

Type B.—The diurnal variation is of this type at two groups of stations. The first group includes nine stations in the Central Provinces, Deccan and South Madras and the Bengal Coast districts, *viz.*:—

Jubbulpore.	Bellary.
Pachmarhi.	Belgaum.
Nagpur.	Trichinopoly.
Poona.	Cuttack.

Chittagong.

The maximum occurs at 2 to 4 P.M. at these stations and on the average of all at 3 P.M.

The amplitude of the variation is least for the northern stations, *viz.*, Pachmarhi and Jubbulpore, for which it averages 1·4 and increases to Bellary, for which it averages 2·6 in amount.

The curves for these stations will be found in Fig. 27, Plate XLV, and in Figs. 1, 7, 9, 11, 13, 15, 17 and 19, Plate XLVI. An examination shows that in all these curves, without exception, there is a slight sudden increase of cloud from about 5 A.M. to 6 A.M. or 7 A.M., followed by little increase until 11 A.M., after which a further moderately rapid increase occurs until about 3 P.M.

The second group of stations at which the diurnal variation is of the Type B includes—

Hazaribagh,	Roorkee,
Patna,	Jaipur,
Allahabad,	Deesa,
Lucknow,	Leh,
Trivandrum	

that is, the majority of the observatories in Northern India.

The variation at the stations in the interior of Northern India except Leh is of smallish amplitude. The maximum occurs between 2 and 4 P.M. and the minimum during the night. At Leh the amount of cloud is almost constant from 8 P.M. to 5 A.M. It thence rises slightly until 7 A.M. and is again constant until 10 A.M., after which it increases rapidly to the maximum of the day at 3·30 P.M.

These stations, almost without exception, show a slight sharp rise about sunrise. The early morning variation or oscillation is fairly well marked at Patna and Hazaribagh, and these stations might perhaps be included in the group, Type C.

The following gives mean data for the two groups of stations (plotted in Figs. 17 and 18, Plate XL) :—

TABLE XCIV.

Hour.	Variation from mean of day		Hour.	Variation from mean of day	
	1st Group.	2nd Group.		1st Group.	2nd Group.
Midnight	−0·63	−0·36	Noon	+0·68	+0·31
1	−0·67	−0·40	13	+0·80	+0·47
2	−0·72	−0·43	14	+0·95	+0·60
3	−0·69	−0·43	15	+0·96	+0·64
4	−0·69	−0·38	16	+0·91	+0·66
5	−0·61	−0·31	17	+0·74	+0·46
6	−0·09	−0·06	18	+0·39	+0·26
7	+0·11	+0·01	19	−0·30	−0·14
8	+0·13	+0·01	20	−0·47	−0·28
9	+0·14	+0·01	21	−0·52	−0·31
10	+0·33	+0·09	22	−0·61	−0·33
11	+0·47	+0·19	23	−0·63	−0·31
			Mean of day	3·35	2·29

The diurnal variation of cloud, *i.e.*, the increase in the day period from 8 A.M. to 3 P.M. and its decrease until 8 P.M. is clearly due to ascensional and convective movements accompanying the rapid day changes of temperature. In the dry interior of Northern

and Central India, the movements are not sufficiently great to give rise to much cloud. In the damper coast districts of Bengal and in the Peninsula, over which moderately damp north-east to east winds obtain, these diurnal convective movements give rise to a very considerable variation of cloud.

Type C.—The diurnal variation at Allahabad, Patna and Hazaribagh, which have been included in the preceding type, might, perhaps more properly, be given as belonging to Type C, that of a double oscillation in which the amplitude of the morning oscillation is much smaller than that of the afternoon oscillation. The following gives comparative data for this group of stations:—

TABLE XCV.

Hour.	Variation from mean of day.	Hour.	Variation from mean of day.
Midnight	−0·31	Noon	+0·31
1	[illegible]	13	+0·45
2	[illegible]	14	+0·55
3	[illegible]	15	+0·51
4	[illegible]	16	+0·33
5	[illegible]	17	+0·14
6	+0·16	18	+0·02
7	[illegible]	19	−0·27
8	[illegible]	20	−0·35
9	+0·05	21	−0·35
10	[illegible]	22	−0·37
11	+0·16	23	−0·32
		Mean of day	5·01

Type D.—The diurnal variation belongs to this type at two stations, *viz.*, Rangoon and Kurrachee. At the first station the variation is well marked. The cloud amount at that station is constant from 8 P.M. to 2 A.M. It thence rises to 7 A.M., and is practically constant during the day hours until 4 P.M., when it begins to fall rapidly and continues to fall until 8 P.M.

The variation at Kurrachee is of small amplitude and the curve similar to that of the cold weather. The amplitude is, on the other hand, large at Rangoon.

The actions giving rise to the diurnal variation of cloud at these stations are:—

(1) Land and sea breezes.
(2) Evaporation.
(3) Convection.

The following gives mean data for this group of stations (plotted in Fig. 19, Plate XL.) :—

TABLE XCVI.

Hour.	Variation from mean of day	Hour.	Variation from mean of day.
Midnight	−0·76	Noon	+0·71
1	−0·93	13	+0·76
2	−0·84	14	+0·88
3	−0·76	15	+0·64
4	−0·56	16	+0·63
5	−0·22	17	+0·50
6	+0·33	18	+0·15
7	+0·65	19	−0·58
8	+0·66	20	−0·76
9	+0·53	21	−0·76
10	+0·48	22	−0·69
11	+0·66	23	−0·74
		Mean of day	2·24

In considering the diurnal variation of cloud it may be assumed that the cloud due to cyclonic storms and accompanying general bursts of rain in the monsoon will, on the average, give rise to a nearly uniform diurnal distribution, and hence that it will at the utmost modify the cloud amount approximately to the same extent throughout the 24 hour period. The diurnal variation disclosed by the data and discussed in the preceding pages may hence be assumed to be chiefly, if not solely, due to periodic causes or actions.

Division of day into five periods, based on the diurnal variation of cloud.—The preceding analysis has hence shown that the diurnal period may, so far as the changes in amount of cloud are concerned, be divided into five intervals.

These are as follows :—

1st.—From 8 P.M. to 4 A.M. in which the processes on the average neutralize each other, and the mean variation of the cloud amount is very small.

2nd.—From 4 A.M. to 6 A.M. or 7 A.M. in which there is a short but rapid increase of cloud due to radiation and conduction, and accompanying the arrest or discontinuance of descensional movement.

3rd.—From 6 A.M. or 7 A.M. to 10 A.M. or 11 A.M. in which the actions of radiation and conduction are in opposition to that of the solar action, the effect of which is at first small but increasing, and which is chiefly exhibited in increase of temperature at this stage or in dissolution of cloud. The resultant changes in the cloud amount during this period vary very considerably in different districts and in different seasons, and may be either (1) actual slight decrease of cloud, (2) constant cloud, and (3) increase of cloud, but less rapidly than in the preceding period from 4 A.M. to 7 A.M.

4th.—From 10 A.M. or 11 A.M. to 3 P.M. or 4 P.M. during which the most important factor is increasing convective movement depending upon the character of the prevailing air currents, more especially in the districts on and near to the coast. The effect of the action is to give a considerable to large increase of cloud, reaching its maximum at 3 to 4 P.M.

5th.—From 3 P.M. or 4 P.M. to 8 P.M. during which convective movement diminishes and finally ceases and descensional movement commences. There is hence a rapid decrease of cloud during this interval.

The preceding division of the day is chiefly based on the fact that the diurnal variation of cloud over nearly the whole of India consists of two oscillations: an early morning oscillation and an afternoon and evening oscillation. These differ largely in relative amplitude in different seasons, the latter being exaggerated in the hot weather and the former in the cool weather, and to a less extent in the rains. It may again be noted here that the only exceptions to this are the Assam stations and the coast stations of Aden and Kurrachee. The chief point of difference between the curves representing the diurnal oscillation at the great majority of stations in India is the character of the transitional change from the morning to the afternoon oscillation.

The chief actions tending to the formation of cloud have been stated in pages 160-1. They may be summed up as follows:—

(1) Cooling due to radiation, conduction or diffusion.

(2) Cooling due to surface or volume mixture of air masses of different temperatures.

(3) Cooling due to ascensional movement from whatever cause arising.

The first two may be termed irreversible processes. The last is reversible if the direction of the movement be reversed. The actions then called into play tend to the disappearance of cloud.

The following is a more complete investigation of the cloud features in each of the five periods of the day (named above) and of the chief actions in each of these periods giving rise to the formation or disappearance of cloud:—

I.—First period of the day from 8 P.M. to 4 A.M.—The variation of the amount of cloud during the first period of the day from 8 P.M. to 4 A.M. is small in amount at all stations and in all seasons.

For example, at 22 out of the 26 stations for which curves are given, the cloud proportion is unchanged in amount during this period of the day during the cold weather and on the mean day of the year. This period of constant cloud (small in amount) is somewhat shorter in the hot weather than in the cold weather season, terminating about 3 A.M.

The chief actions or conditions in operation from 8 P.M. to 4 A.M. are—

(1) General compression or slight descensional movement during the night tending to diminish in amount, as the rate of decrease of temperature diminishes during the night.

(2) Special descensional movement in mountain valleys and at the foot of large mountain ranges. These movements tend to give rapid decrease of cloud followed by clear skies.

(3) Conduction and radiation.—These processes act in opposite directions, but on the whole tend to give increased cloud.

(4) Almost entire suspension of air movement in the plains of the interior of India during the night hours on at least three nights out of four on the average of the year. This of course accompanies the absence of convective movements.

During the period from 10 P.M. or 11 P.M. to 3 A.M. or 4 A.M. the chief actions are slow, descensional movement tending to diminish cloud and radiation and conduction tending to increase cloud. These actions, as shown by the actual results, almost balance each other until about 3 A.M. or 4 A.M., the variations in the amount of cloud during this period being on the average very small. This is at once evident from an examination of the curves, more especially the type curves in Plate XL.

The following give a connected statement of the actions in operation during this period and the following periods:—

After sunset, especially in fine clear weather, the temperature of the earth's surface and lower air strata diminishes rapidly. Convective movements cease in the lower strata after 4 or 5 P.M., and in the middle atmospheric strata (as shown by the homogeneity of the air) after 5 P.M. to 5-30 P.M. A slow movement of contraction and descent follows for some hours. In the earlier night hours the tendency of these changes and actions (*i.e.*, cessation of convective movements and the commencement and continuation of slow descensional movement) is to diminish the amount of cloud These actions are vigorous in the dry weather and slight to moderate in total amount according to position with reference to the seas and hills. Hence in all seasons the amount of cloud falls to a minimum during the evening and early morning hours.

This period as a rule lasts from about 7 or 8 P.M., to 3 or 4 A.M. During this period the middle and upper air strata having been slowly cooling due to radiation, chiefly from the dust particles contained in the air surface, and by conduction from the air to the dust particles or from one air stratum to another air stratum (adjacent to it) of different temperatures and humidity. If any such air stratum be not very far from its saturation point, there are hence invariably at work actions which tend to reduce it to that point, and consequently for condensation to commence and give rise to the formation of cloud. As these actions produce no visible effect until they reach the actual point of saturation, this formation of cloud will in all cases occur suddenly and rapidly. Hence if this explanation be correct there will be a marked tendency to a brief rapid increase of cloud in the early morning hours. I have, when travelling at elevations of over 10,000 feet in the Himalayas, witnessed on more than one occasion the change from a clear sky to a sky completely obscured by cloudor fog at a moderate elevation in less than ten minutes, due apparently to some similar action. An examination of the cloud curves in Plates XL to XLVII shows this to be one of the most prominent features of the cloud variation.

The contrast between these two sets of actions (from 9 A.M. to 4 P.M. and from 4 P.M. to 7 or 8 P.M.) is especially marked in fine weather over the Himalayas where invariably cloud of the cumulus type forms and accumulates, increasing in volume and depth until about 3 or 4 P.M. It thence thins off and gradually disappears, and usually by 5-30 P.M. skies are again clear.

An interesting inference from these facts is that the actual mean amount for this period of the day in the dry season differs little from the mean amount of cloud due to disturbed weather during that season. If this be the case, the following gives an approximate value

of the amount of disturbance (as measured by its cloud producing effect) during the cold and hot weather seasons :—

Lahore	2·7	Cuttack	1·0
Allahabad	1·6	Jubbulpore . . .	1·5
Jaipur	2·5	Nagpur	1·5
Patna	1·5	Poona	0·5
Chittagong	1·0	Belgaum	0·5

II. Second period from 4 A.M. to 6 A.M. or 7 A.M.—It has been pointed out in the preceding discussion generally that there is a tendency to an increase of cloud during this period in all seasons and at all stations almost without exception in India. It is as regular a feature as the increase of air pressure between 4 A.M. and 10 A.M.

The following are the chief inferences respecting this formation of morning cloud :—

(1) It occurs at all stations in all seasons, the amount of the increase differing however, very considerably with season and locality.

(2) It is during the rains or wet season marked at the coast and interior stations subject to the full influence of the monsoon. It is for example very pronounced at Allahabad, Rangoon, Deesa, Trichinopoly and Bombay.

(3) It occurs markedly in Southern India during the retreating south-west monsoon and to a less extent in May when there is a large indraught from the neighbouring sea areas. It is, on the other hand, very feebly exhibited in Northern India during this period.

(4) It is clearly exhibited in North-Western India during the cold weather, more especially from December to February, the period of cold weather storms. It is, for example, marked at this season in the curves for Lahore, Deesa, Jaipur, Rangoon and Chittagong. It is also clearly shown at the Peninsular stations, more especially Poona, Belgaum and Trichinopoly.

(5) In the hot weather it is marked in the Deccan, Southern India and in the coast districts represented by Kurrachee, Cuttack and Rangoon. It is also exhibited clearly, although slightly, at stations in the interior of Northern India during this period.

(6) It forms the chief feature of the cloud variation at certain stations, *viz.*: Sibsagar, Dhubri, Goalpara, Kurrachee, Chittagong and Rangoon, and probably Bombay and Madras (situated either in the damp Assam Valley or on the sea coast). It is so marked that it gives rise at these stations to an oscillation in the morning, the period and amplitude of which on the mean of the year are shown in the following table :—

TABLE XCVII.

STATION.	Period of oscillation in the morning.	Maximum epoch	Amplitude.	Ratio to mean cloud amount.
Sibsagar . . .	3 A.M. to 9 A.M.	9 A.M.	0·4	0·1
Dhubri . . .	5 A.M. to 7 A.M.	7 A.M.	0·7	0·2
Goalpara . . .	4 A.M. to 8 A.M.	8 A.M.	0·5	0·1
Kurrachee . . .	4 A.M. to 7 A.M.	7 A.M.	0·4	0·1
Chittagong . . .	4 A.M. to 6 A.M.	6 A.M.	0·5	0·1
Rangoon . . .	4 A.M. to 7 A.M.	7 A.M.	1·4	0·3
Bombay . .	4 A.M. to 7 A.M.	7 A.M.	0·6	0·2

(7) It is, on the whole, most marked during the period when the weather is finest and most serene, as shown by the following:—

Area.	Period when early morning oscillation is most marked.	Period.
Punjab and North Western India	Retreating south-west monsoon and cold weather.	November to January.
Bihar, Bengal and Orissa . .	Retreating south-west monsoon	October and December.
Peninsula, North . . .	Retreating south-west monsoon and cold weather.	November to January.
Peninsula, South . . .	Cold weather	December to February.

(8) It is slightly exhibited at the coast stations in the rains.

This period of slight but rapid increase of cloud is due chiefly to the processes of radiation and conduction in the middle and higher atmospheric strata from about 4 A.M. to 7 A.M. as has been fully explained in page 191.

A reference to the seasonal curves in Plate XL will show at once that the increase of cloud at 4 to 5 A.M. is common to the whole of India. It is more pronounced in the damp coast districts and Assam than in the dry interior districts of Northern and Central India. It is, on the whole, most pronounced in the dry cold-weather. The most important feature is the suddenness of the change. During the night hours the cloud amount varies very slightly. A critical period favourable for rapid condensation and cloud formation sets in about 4 A.M., and a large increase occurs during the next two hours. Numerous examples may be found of this action in the curves given in Plates XLI to XLVI. The most striking are perhaps the following:—

Station.	Period or season.
Deesa.	Hot weather.
Allahabad.	Ditto.
Hazaribagh	Ditto.
Belgaum.	Ditto.
Bellary.	Ditto.
Trichinopoly.	Ditto.
Poona.	July and September

This action commences about 4 A.M. when the air movement is exceedingly feeble. No additional action comes into operation at that time. The air up to a considerable height cools down slowly during the night by the process of radiation into space and to the earth and of conduction consequent on the cooling of the earth and the adjacent strata. The reduction of temperature in the lower and middle atmospheric strata is probably a slow process, but it may be sufficient to give rise to condensation and cloud formation in any damp stratum if such be present. The process of condensation sets free a considerable amount of energy which probably chiefly acts as a slight upward impulse. The continuance of this action and the cooling of the cloud masses by radiation tends to increase cloud until shortly after sunrise when a new and discontinuous action (the solar radiation) is brought into play. An examination of the curves will show that the variation of cloud from 4 A.M. to 7 A.M. is in strict accordance with this explanation.

III. Third period of the day from 6 A.M. or 7 A.M. to 10 A.M. or 11 A.M.—The variation of the amount of cloud during the third period of the day, from 7 A.M. to 10 A.M. or 11 A.M., differs more largely with season and locality than during any other period of the day.

The direct action of the sun upon the atmosphere containing any cloud undoubted

tends to dissipate the cloud by absorption of heat and evaporation. The direct heating of the surface of the earth by the solar radiation and the consequent heating of the lowest stratum of the air by contact tends to give rise to expansion and to convective movements. Both of these actions or movements, the first by elevating the middle strata, the second, by carrying up air which has, especially in Assam and Kashmir, absorbed a considerable quantity of moisture (in consequence of the absence of air movement during the night), tends to give rise to increased cloud. This action is probably small in the open Gangetic Plain, but is probably large in closed valleys like Assam and Kashmir.

In addition to these there are others, such as a change from land to sea breezes or the increasing intensity of the sea winds of the rainy season due to the heating of the interior. The effect of these changes is, however, as a rule, not perceptible at this period of day in the formation of cloud as the changes are in the initial stage. The combination of these three actions or processes of which the effect of the first, the direct absorption of the solar heat by the clouds, is opposite to those of the second and third actions of movement of expansion and of convective movement, may give rise either to—

(1) actual diminution in the amount of cloud as would probably be the case over the greater part of the interior of India;

(2) suspension of increase of cloud, and hence of almost constant cloud on the average from 6 A.M. to 11 A.M. or noon.

(3) increase of cloud at a slower rate during the period from 6 or 7 A.M. to 10 A.M. or 11 A.M. than during the previous period. This is observed chiefly at coast stations, more especially Chittagong and Rangoon, and in mountain valleys as represented by Leh.

The heating effect on the atmosphere and hence the dissipation of any cloud present is common to the whole of India. The amount of expansion in any given interval during the day hours, and hence any effect it may have in producing cloud, is greatest in the interior where the diurnal range is greatest. Similarly the effect of convective movements will differ very considerably in different parts of India. It will depend largely upon the actual amount of cloud in the morning, the rate at which temperature increases and the character of the soil, and will hence be greatest in the dry interior and slight in the coast districts and Assam. A consideration of the varying intensity of those actions in different parts of India hence explains—

(1) The increase in the cloud amount during this period in Assam and at most of the coast stations.

(2) The uniformity or slight decrease of amount during this period at most stations in the interior of Northern India.

(3) The increase during this period at Leh.

IV. Fourth period from 10 A.M. or 11 A.M. to 3 P.M. or 4 P.M.—The fourth period of the day, from about 10 A.M. or 11 A.M. to about 3 P.M., is marked by a rapid and considerable increase of cloud due to the vigorous convective movement during this interval. This movement usually commences on the large scale about 10 A.M. and increases in volume and intensity until shortly after the maximum temperature of the day is observed in the lower atmospheric strata. (For certain considerations in connection with this action see Cleveland Abbé's Dynamics of the Atmosphere, Chapter VI).

The chief features during this period are—

(1) More or less rapid increase of cloud.

(2) The increase during this period in the cold weather is slight to moderate in amount in the North-Western Provinces, Chota Nagpur, Bihár and Rajputana, and is large in the Central Provinces, Deccan and Southern India, the hottest area in India during the period.

(3) The increase is considerable to large in amount over the whole of India in the hot weather. It is absolutely greatest, on the mean of the period, in Orissa, the Central Provinces and Deccan, more especially at the stations on the outside limits of the sea breezes (*e g.*, Cuttack, Belgaum and Poona).

(4) The increase during this period of the day in the rainy season is small in amount over the whole area to which the full influence of the humid monsoon winds extends. It is moderate in amount in the Deccan and Upper India, and is absolutely greatest at Bellary.

(5) In the retreating south-west monsoon the increase is slight in amount in Upper India. It is moderate in Bihar, Chota Nagpur and Rajputana, and is large in amount in Orissa, Bengal, the interior of the Peninsula and Southern India.

The preceding facts hence show that the increase of cloud is directly related to the intensity of the thermal conditions, or more strictly speaking, to their intensity in giving rise to convective movements. The humidity of the air is a subsidiary factor of little importance. Of course, this is in accordance with the general fact that no matter how dry a mass of air is, its temperature can always be reduced sufficiently by upward or convective movement to give rise to condensation and formation of cloud.

(It may be noted that the increase of cloud theoretically occurs not only with ascensional or convective movement, but with general upward expansion of the air due to increasing temperature, but it is very doubtful whether, except under rare conditions, the latter is an efficient cause of cloud formation practically).

The increase due to convective action is marked in all months and at all stations; but is, as a rule, greatest in the season when the convective movement is most vigorous, or in the hot weather from March to May or June. The following gives the epochs of the maximum amount of cloud due to this action in the four seasons of the year at all stations with the exception of Aden, Chittagong, Dhubri, Goalpara, Kurrachee and Sibsagar, where convective action is probably feeble ;—

TABLE XCVIII.

STATION.	Cold weather (January and February)	Hot weather (March to May)	South-west monsoon rainy season (June to September).	Retreating south-west monsoon season (October to December).	Mean of year
Agra	4 P.M.	3 P.M.	3 P.M.	3 P.M.	3 P.M.
Allahabad	4 P.M.	5 P.M.	2 P.M.	2 P.M.	3 P.M.
Belgaum	3 P.M.	2 P.M.	5 P.M.	3 P.M.	3 P.M.
Bellary	3 P.M.	4 P.M.	2 P.M.	2 P.M.	3 P.M.
Cuttack	3 P.M.	4 P.M.	4 P.M.	4 P.M.	4 P.M.

TABLE XCVIII—concld.

Station.	Cold weather (January and February).	Hot weather (March to May).	South-west monsoon rainy season (June to September).	Retreating south-west monsoon season (October to December).	Mean of year.
Deesa	5 P.M.	4 P.M.	4 P.M.	4 P.M.	4 P.M.
Hazaribagh	2 P.M.	3 P.M.	2 P.M.	2 P.M.	3 P.M.
Jaipur	4 P.M.	3 P.M.	4 P.M.	4 P.M.	4 P.M.
Jubbulpore	5 P.M.	4 P.M.	5 P.M.	4 P.M.	5 P.M.
Lahore	3 P.M.	4 P.M.	2 P.M.	4 P.M.	3 P.M.
Leh	4 P.M.	4 P.M.	2 P.M.	4 P.M.	3 P.M.
Lucknow	4 P.M.	1 P.M.	2 P.M.	2 P.M.	3 P.M.
Nagpur	4 P.M.	4 P.M.	3 P.M.	3 P.M.	4 P.M.
Pachmarhi	3 P.M.	4 P.M.	3 P.M.	3 P.M.	3 P.M.
Patna	2 P.M.	5 P.M.	2 P.M.	3 P.M.	4 P.M.
Poona	5 P.M.	4 P.M.	4 P.M.	4 P.M.	4 P.M.
Rangoon	5 P.M.	4 P.M.	5 P.M.	2 P.M.	4 P.M.
Roorkee	3 P.M.	6 P.M.	1 P.M.	4 P.M.	4 P.M.
Trivandrum	5 P.M.	5 P.M.	5 P.M.	5 P.M.	5 P.M.
Trichinopoly	6 P.M.	6 P.M.	5 P.M.	4 P.M.	5 P.M.
Mean of all stations	4 P.M.	4 P.M.	3 P.M.	3 P.M.	4 P.M.

V. The fifth period from 4 P.M. to 8 P.M.—The following are the chief features of the variation of the cloud amount during the fifth period of the day, from 4 P.M. to 7 P.M. or 8 P.M.:—

(1) A more or less rapid reduction in the amount of cloud occurs over the whole of India in all seasons during this period of the day.

(2) This reduction of cloud during this period is similar in amount to the increase during the previous five or six hours from 10 A.M. to 4 P.M.

(3) In the cold weather season the diminution of cloud during this period of the day is large in the Peninsula (including the Central Provinces) and moderate to slight in Northern and Central India

(4) The reduction in the hot weather is large over the whole of India and is greatest in actual amount at Leh and in the Punjab, Rajputana and Deccan areas.

(5) In the rains the reduction varies somewhat irregularly in amount. It is small in North-Eastern India, the Deccan and Central Provinces, moderate in the North-Western Provinces, and large in the Punjab, Rajputana and the South Deccan.

(6) It is slight to moderate in amount over the whole of Northern India during the retreating south-west monsoon and moderate to large at the coast stations of Rangoon and Chittagong and in the Peninsula (more especially at Bellary, Trichinopoly and Poona).

The change during this period is opposite to that during the preceding period of the day, from 10 A.M. to 3 P.M. or 4 P.M., and is directly related to it in amount, and on the whole proceeds more rapidly than the rise to which it is related. It is evidently due to the gradual diminution and cessation of the convective movements which occur between 3 P.M. or 4 P.M. and 7 P.M., and the measure of this effect is the intensity of the thermal actions and of the convective movements when they are greatest (between 2 P.M. and 3 P.M.) The other actions tending to produce or dissipate cloud during this period are radiation from the clouds, absorption of the solar heat by the clouds and air movement. The effect of these is however small as compared with that of the decrease of convective movement.

The combination of the rapid increase of cloud accompanying increasing convective action and decrease accompanying diminishing convective action in the diurnal period gives a marked day oscillation in the diurnal variation of cloud. The period of this oscillatory variation is from 11 A.M. to 10 P.M.

The following table gives the period for each season of the year, and for the whole year of this oscillation at each of the stations at which satisfactory and trustworthy observations of this element have been taken:—

TABLE XCIX.

STATION.	January and February.	March to May.	June and September.	July and August.	October to December.	YEAR.
Agra	Noon to Midnight.	Noon to 8 P.M.	11 A.M. to 11 P.M.	9 A.M. to 11 P.M.	11 A.M. to 6 P.M.	9 A.M. to 8 P.M.
Allahabad	1 P.M. to 10 P.M.	Noon to 8 P.M.	10 A.M. to 10 P.M.	10 A.M. to 9 P.M.	11 A.M. to 7 P.M.	9 A.M. to 9 P.M.
Belgaum	10 A.M. to 8 P.M.	11 A.M. to 8 P.M.	9 A.M. to 8 P.M.	9 A.M. to 8 P.M.	11 A.M. to 11 P.M.	11 A.M. to 8 P.M.
Bellary	11 A.M. to 11 P.M.	11 A.M. to Midnight	1 A.M. to 8 P.M.	9 A.M. to 10 P.M.	9 A.M. to 10 P.M.	11 A.M. to 10 P.M.
Cuttack	Noon to 11 P.M.	1 P.M. to 7 P.M.	7 A.M. to 11 P.M.	8 A.M. to 11 P.M.	9 A.M. to 10 P.M.	9 A.M. to 9 P.M.
Deesa	11 A.M. to 8 P.M.	Noon to 9 P.M.	1 P.M. to 9 P.M.	1 P.M. to 9 P.M.	11 A.M. to 10 P.M.	1 A.M. to 9 P.M.
Hazaribagh	11 A.M. to 0 P.M.	10 A.M. to 9 P.M.	10 A.M. to 8 P.M.	8 A.M. to 8 P.M.	9 A.M. to 8 P.M.	10 A.M. to 9 P.M.
Jaipur	11 A.M. to 8 P.M.	11 A.M. to 9 P.M.	10 A.M. to 10 P.M.	1 P.M. to 9 P.M.	11 A.M. to 7 P.M.	11 A.M. to 9 P.M.
Jubbulpore	10 A.M. to 11 P.M.	Noon to 8 P.M.	11 A.M. to 9 P.M.	3 P.M. to 11 P.M.	Noon to 8 P.M.	Noon to 8 P.M.
Lahore	11 A.M. to 11 P.M.	2 P.M. to 8 P.M.	11 A.M. to 9 P.M.	11 A.M. to 11 P.M.	11 A.M. to 7 P.M.	11 A.M. to 11 P.M.
Leh	11 A.M. to 9 P.M.	8 A.M. to 10 P.M.	8 A.M. to 8 P.M.	8 A.M. to 9 P.M.	9 A.M. to 9 P.M.	9 A.M. to 9 P.M.
Lucknow	Noon to 10 P.M.	10 A.M. to 9 P.M.	Noon to 8 P.M.	Noon to 8 P.M.	9 A.M. to 8 P.M.	Noon to 8 P.M.
Nagpur	11 A.M. to 8 P.M.	10 A.M. to 10 P.M.	10 A.M. to 10 P.M.	11 A.M. to 10 P.M.	10 A.M. to 8 P.M.	9 A.M. to 9 P.M.
Pachmarhi	10 A.M. to 8 P.M.	10 A.M. to 8 P.M.	10 A.M. to 8 P.M.	9 A.M. to 4 P.M.	9 A.M. to 9 P.M.	9 A.M. to 8 P.M.
Patna	11 A.M. to 11 P.M.	10 A.M. to 9 P.M.	11 A.M. to 11 P.M.	9 A.M. to 8 P.M.	10 A.M. to 9 P.M.	11 A.M. to 8 P.M.
Poona	Noon to 8 P.M.	9 A.M. to 10 P.M.	8 A.M. to 8 P.M.	Noon to 8 P.M.	11 A.M. to 8 P.M.	11 A.M. to 8 P.M.
Rangoon	Noon to 8 P.M.	11 A.M. to 10 P.M.	8 A.M. to 9 P.M.	8 A.M. to 10 P.M.	10 A.M. to 8 P.M.	10 A.M. to 7 P.M.
Roorkee	Noon to 11 P.M.	Noon to 11 P.M.	11 A.M. to 9 P.M.	11 A.M. to 8 P.M.	1 P.M. to 9 P.M.	8 A.M. to 9 P.M.
Trichinopoly	8 A.M. to 10 P.M.	Noon to 11 P.M.	Noon to 11 P.M.	1 P.M. to 11 P.M.	11 A.M. to 8 P.M.	Noon to 8 P.M.
Trivandrum	2 P.M. to Midnight.	2 P.M. to 10 P.M.	2 P.M. to 9 P.M.	2 P.M. to 9 P.M.	1 P.M. to 9 P.M.	1 P.M. to 8 P.M.

Comparison of the chief facts of the diurnal variation of cloud with those of temperature, air movement and aqueous vapour pressure ;—The curves giving the diurnal variation of cloud differ entirely from those of temperature and air movement. The latter curves have only one

maximum and minimum. They, on the other hand, agree with those of air pressure and aqueous vapour pressure in having generally two maxima and minima. They differ largely from those of air pressure, more especially in the following features:—

(1) The epochs of the maxima and minima values occur at unequal intervals, whereas those of air pressure occur at very nearly equal intervals.

(2) The amplitudes of the two oscillations differ far more largely with season and locality than the amplitudes of the two oscillations of the air pressure.

They agree, on the other hand, with the aqueous vapour pressure curves in these two respects.

As might further be expected the Besselian resolution of the diurnal variation of cloud differs entirely from the corresponding resolution of the air pressure, velocity and temperature. The relations of the amplitudes and the epochs differ so widely and irregularly as to show there is no direct relation between the corresponding elements of the resolution of cloud and those of the three other elements named above.

The following gives the more noteworthy differences between these constants:—

(1) The epochs of the maximum and minimum values of the first and second components of the temperature formula are remarkably constant throughout the year, and at all stations in India the maximum epochs of the first component average 2-15 P.M. and of the second component 1-0 A.M and P.M. On the other hand, the corresponding epochs for cloud vary largely with season and moderately with locality, ranging, for example, in the case of the first component beween 6-37 A.M. and 0-51 P.M. at the seven stations selected as representative of the plains stations in India, and the constants of which are given in Tables C to CVI, pages 198 to 201.

(2) The ratios of the amplitudes of the first and second components in the case of temperature and pressure vary very slightly with locality and season. They vary very largely from month to month in the cases of cloud and aqueous vapour.

The preceding remarks indicate that the harmonic formulæ obtained by Bessel's method representing the diurnal variation of aqueous vapour pressure and cloud present several points of agreement. The following are the more important:—

(1) The amplitude of the first component in each has two maxima and minima values. The maxima values in each occur about the same period of the year, *viz.*, in April or May and in October. The absolute minimum is in July or August, the height of the rains, in both cases. The secondary minimum of each is very variable in its occurrence, but at most stations in the interior of Northern India is in December or January. At several stations there are three or four maxima and minima in the course of the year.

(2) The monthly values of the amplitude of the second component vary largely throughout the year, but to a less extent than those of the first component. They have in most cases two maxima and minima values. The first and absolute maximum occurs in the interior of India in April or May and the second in October, that is, in the two driest periods of the year. The epachs of the minima are more variable in their occurrence, but in most cases are earliest in July or August and latest in December or January.

The following table gives for reference the amplitudes and phases of the first four components of the Besselian resolution of the diurnal variation of cloud at seven selected stations in different parts of India:—

TABLE C.—*Constants of the periodical formula (II) for the diurnal variation of cloud proportion at Deesa.*

MONTH.	U_1.	u_1.	U_2.	u_2.	U_3	u_3	U_4.	u_4
		° ′		° ′		° ′		° ′
January	0·980	245 51	0·119	263 14	0·177	64 36	0·073	113 24
February	0·850	276 33	0·114	194 46	0·227	51 49	0·051	124 27
March	0·577	266 43	0·206	323 4	0·019	328 0	0·103	110 33
April	0·444	280 39	0·190	279 25	0·040	33 41	0·051	124 37
May	0·373	92 0	0·638	300 1	0·069	126 12	0·082	74 26
June	1·119	294 12	0·451	229 30	0·250	86 34	0·175	145 13
July	0·242	35 55	0·095	185 25	0·259	90 0	0·134	254 24
August	0·557	281 43	0·162	297 12	0·244	352 14	0·053	165 42
September	0·735	283 56	0·209	280 30	0·285	117 22	0·110	70 54
October	0·509	210 51	0·384	325 49	0·329	104 25	0·054	217 30
November	0·540	239 47	0·220	330 39	0·101	113 16	0·074	107 13
December	0·512	263 37	0·090	108 50	0·047	9 52	0·034	149 37
YEAR	0·504	267 57	0·177	287 49	0·139	79 15	0·044	131 19

TABLE CI.—*Constants of the periodical formula (II) for the diurnal variation of cloud proportion at Patna*

MONTH.	U_1.	u_1.	U_2	u_2	U_3	u_3	U_4	u_4
		° ′		° ′		° ′		° ′
January	0·530	238 44	0·217	312 57	0·115	216 52	0·120	23 8
February	0·365	272 49	0·251	276 25	0·009	110 33	0·038	88 30
March	0·287	252 19	0·380	290 58	0·067	138 1	0·075	80 2
April	0·207	258 35	0·237	335 36	0·069	125 32	0·158	77 12
May	0·272	251 6	0·437	287 2	0·131	167 39	0·019	34 30
June	0·708	281 44	0·325	283 11	0·207	192 1	0·126	131 9
July	0·352	276 52	0·070	355 55	0·161	30 14	0·123	167 19
August	0·253	325 18	0·203	252 11	0·168	280 18	0·115	59 38
September	0·330	279 14	0·139	297 51	0·018	77 28	0·105	33 23
October	0·363	256 46	0·190	6 40	0·054	254 56	0·084	83 8
November	0·204	271 58	0·257	294 10	0·141	135 52	0·009	290 33
December	0·358	276 25	0·192	287 52	0·104	146 46	0·055	201 25
YEAR	0·332	269 8	0·217	296 20	0·047	172 44	0·054	81 25

TABLE CII.—*Constants of the periodical formula (II) for the diurnal variation of cloud proportion at Dhubri.*

MONTH.	U_1.	u_1.	U_2.	u_2.	U_3.	u_3.	U_4.	u_4.
		° ′		° ′		° ′		° ′
January	0·462	268 38	0·241	149 36	0·311	24 30	0·188	2 26
February . . .	0·760	288 49	0·313	351 55	0·066	75 7	0·095	67 45
March	0·622	256 42	0·162	263 58	0·104	165 34	0·155	70 45
April	1·034	353 37	0·124	204 54	0·198	136 14	0·145	281 33
May	0·861	12 57	0·451	197 50	0·389	47 30	0·123	319 57
June	0·895	318 51	0·555	297 57	0·592	22 9	0·106	138 3
July	0·790	1 27	0·264	0 13	0·306	135 40	0·175	8 13
August . . .	0·662	335 39	0·702	308 38	0·344	86 30	0·242	109 2
September . . .	0·674	44 13	0·462	308 8	0·501	87 1	0·285	187 40
October . . .	0·325	258 27	0·336	305 32	0·292	77 9	0·188	60 2
November . . .	0·211	289 23	0·066	162 23	0·133	120 49	0·136	282 18
December . . .	0·258	265 46	0·230	152 33	0·201	52 16	0·171	332 32
YEAR .	0·479	320 20	0·175	289 22	0·228	73 24	0·042	30 15

TABLE CIII.—*Constants of the periodical formula (II) for the diurnal variation of cloud proportion at Rangoon.*

MONTH.	U_1.	u_1.	U_2.	u_2.	U_3.	u_3.	U_4.	u_4.
		° ′		° ′		° ′		° ′
January	0·721	274 32	0·454	287 19	0·469	94 46	0·047	76 33
February . . .	0·636	230 18	0·363	299 24	0·326	83 40	0·186	140 54
March	0·980	271 3	0·462	305 45	0·409	93 39	0·093	62 37
April	1·349	254 50	0·378	298 56	0·401	98 37	0·160	353 54
May	2·157	255 33	0·235	317 46	0·309	76 30	0·275	90 0
June	0·913	251 9	0·220	309 16	0·195	41 3	0·058	90 0
July	0·658	244 32	0·196	276 26	0·185	17 57	0·051	64 26
August . . .	0·841	256 43	0·189	284 24	0·184	35 56	0·095	112 15
September . . .	0·983	271 20	0·136	223 48	0·166	69 36	0·204	87 45
October . . .	1·745	297 29	0·018	220 36	0·231	160 0	0·153	67 47
November . . .	1·385	274 53	0·293	246 14	0·257	139 25	0·139	68 26
December . . .	1·470	243 45	0·358	317 16	0·196	111 12	0·246	125 45
YEAR .	1·112	262 15	0·254	293 56	0·223	86 24	0·118	83 11

TABLE CIV.—*Constants of the periodical formula (II) for the diurnal variation of cloud proportion at Nagpur.*

MONTH.	U_1.	u_1.		U_2.	u_2.		U_3.	u_3.		U_4.	u_4.	
		°	′		°	′		°	′		°	′
January	0·579	257	20	0·296	311	43	0·252	130	20	0·029	141	9
February	0·636	248	2	0·311	336	5	0·226	81	20	0·124	245	43
March	0·593	222	12	0·416	323	42	0·310	126	12	0·058	300	7
April	1·078	189	53	0·877	335	41	0·357	92	5	0·069	223	3
May	1·177	206	36	1·237	331	37	0·258	127	46	0·159	119	47
June	0·270	193	16	0·382	0	27	0·125	152	25	0·059	352	9
July	0·254	297	10	0·130	17	2	0·064	305	26	0·068	101	48
August	0·498	233	34	0·125	54	24	0·043	59	16	0·044	71	34
September	0·924	235	5	0·295	343	2	0·060	56	39	0·113	85	57
October	1·266	234	27	0·582	16	41	0·270	143	51	0·042	90	0
November	0·620	244	11	0·211	41	10	0·175	140	19	0·022	230	32
December	0·605	260	1	0·077	289	51	0·199	75	7	0·068	281	48
YEAR	0·646	229	42	0·369	315	24	0·166	116	6	0·022	50	32

TABLE CV.—*Constants of the periodical formula (II) for the diurnal variation of cloud proportion at Bellary.*

MONTH.	U_1.	u_1.		U_2.	u_2.		U_3.	u_3.		U_4.	u_4.	
		°	′		°	′		°	′		°	′
January	0·747	234	58	0·028	92	3	0·110	148	3	0·036	67	1
February	0·506	207	50	0·273	337	51	0·107	93	13	0·055	22	23
March	0·804	239	31	0·381	318	56	0·207	132	15	0·152	19	9
April	1·409	173	19	0·693	331	22	0·536	100	38	0·113	274	3
May	1·012	168	57	0·466	286	50	0·375	134	34	0·144	360	0
June	0·943	229	41	0·196	17	47	0·267	161	38	0·118	96	49
July	0·585	256	4	0·176	309	28	0·140	72	28	0·026	30	35
August	1·034	243	13	0·132	14	28	0·060	98	40	0·190	109	57
September	1·011	206	0	0·480	355	42	0·098	168	14	0·116	116	7
October	1·227	239	23	0·542	31	44	0·192	130	9	0·093	117	23
November	1·471	257	55	0·218	331	26	0·395	97	43	0·050	329	50
December	1·221	253	35	0·134	237	51	0·096	161	10	0·116	183	57
YEAR	0·857	227	8	0·241	342	51	0·193	121	38	0·044	48	41

TABLE CVI.—*Constants of the periodical formula (II) for the diurnal variation of cloud proportion at Aden.*

MONTH.	U_1.	u_1. °	u_1. '	U_2.	u_2. °	u_2. '	U_3.	u_3. °	u_3. '	U_4.	u_4. °	u_4. '
January . . .	1·837	342	13	0·836	166	48	0.432	44	32	0·184	334	33
February . . .	2·220	338	41	0·743	165	30	0·321	4	39	0·106	41	57
March . . .	2·290	335	16	0·669	179	24	0·198	78	55	0·080	68	52
April . . .	1·439	328	58	0·581	222	4	0·054	97	23	0·104	94	24
May . . .	0·601	335	37	0·536	236	11	0·237	96	48	0·068	162	6
June . . .	0·736	24	29	0·166	207	39	0·282	74	20	0·336	51	32
July . . .	0·776	97	15	0·167	195	17	0·192	67	42	0·126	73	26
August . . .	1·400	59	6	0·425	229	52	0·241	219	26	0·119	167	50
September . . .	0·897	0	23	0·394	208	39	0·641	58	43	0·155	27	13
October . . .	0·326	292	0	0·388	219	9	0·144	82	2	0·119	12	10
November . . .	0·859	0	4	0·639	146	36	0·193	109	22	0·133	228	59
December . . .	1·614	340	16	0·713	158	37	0·030	45	0	0·111	311	20
YEAR . .	1·026	350	38	0·452	188	39	0·189	66	0	0·054	37	30

The following is a summary of the frequency of clouds observed at different elevations during the two periods of the year, *viz.*, November to May and June to October 1898—1900 derived from cloud measurements taken at Allahabad (*vide* memoir on the "Report on cloud observations and measurements in the plains of the North-Western Provinces of India during the period December 1898 to March 1900," Vol. XI, Indian Meteorological Memoirs) :—

ELEVATION IN FEET.	FREQUENCY OF CLOUDS AT DIFFERENT ELEVATIONS.																		REMARKS.
	NOVEMBER TO MAY.									JUNE TO OCTOBER.									
	Ci.	Ci. S.	Ci. Cu.	A-Cu.	S-Cu.	N.	Cu	Fr-Cu.	Cu-N.	Ci.	Ci. S.	Ci Cu.	A-Cu.	S-Cu.	N	Cu	Fr. Cu.	Cu-N.	
0 to 8,000 . .	9	...	...	14	...	...	23	2	8	2	...	...	17	...	4	17	...	6	No observations were taken of alto-stratus or stratus clouds.
8,000 to 16,000 .	6	...	2	77	1	...	2	1	5	7	...	...	27	...	...	2	...	1	
16,000 to 24,000	21	1	3	78	...	1	...	...	...	5	...	...	12	...	...	...	...	1	
24,000 to 32,000	20	1	4	35	...	...	...	...	1	5	...	3	5	...	...	1	...	...	
32,000 to 40,000	31	1	2	13	...	...	...	...	...	9	...	...	2	...	...	...	...	...	
40,000 to 48,000	30	2	2	3	...	...	...	...	...	5	...	1	...	...	...	...	...	...	
48,000 to 56,000	10	1	...	2	...	...	...	...	...	3	...	1	...	...	...	...	...	...	
56,000 to 64,000	11	...	...	2	...	...	...	...	...	3	...	...	...	...	...	...	...	...	
64,000 and above	21	1	2	4	...	...	...	...	...	3	...	...	1	...	...	...	...	...	

The preceding data indicate that cirrus clouds are most frequent between 16,000 and 48,000 feet, and alto-cumulus clouds between 8,000 and 32,000 feet.

CHAPTER VII.

WINDS.

Air movement of the Cold Weather months (January and February).—The lower air movement over nearly the whole of India during this period forms an integral and important part of the north-east monsoon circulation over the whole Indian monsoon region. It is, it may be noted, in no way related to the Central Asian anticyclone from the air movement due to which it is cut off by the great barrier of the Himalayas. It is, however, probable that the steady and moderately strong drift from the north in Burma (where the river valleys and mountain ranges run north and south) may be to some slight extent a continuation of air movement in the eastern quadrant of that anticyclone. The general conditions in Upper Burma strongly resemble those of Assam and suggest that it is almost as largely cut off from northerly influence as the latter area.

Over the Indian seas moderate north-east winds prevail steadily throughout the whole period, averaging 2 in force in the north of the Bay of Bengal and Arabian Sea and increasing to force 3 to 4 in the south of these seas and the equatorial belt. In India the air movement is from the interior to the coasts, the direction in different parts being determined to some extent by the lie of the river valleys. The lower air movement in Northern India is hence of continental origin, commencing as a feeble drift in Upper India and increasing in intensity in its passage over Northern and Central India, and thence advancing across the Bengal and Orissa coasts on the one hand and the coasts of Sind and Kathiawar into the neighbouring seas on the other hand. The air movement across the Bengal and Burma coasts is continued as a general drift across the Bay of Bengal and the Peninsula, and thence passes out into the Arabian Sea affecting very slightly the west coast districts which are sheltered by the West Ghats. It thence in the Arabian Sea forms part of the general air movement towards the equatorial belt.

As already stated, this general lower air movement in India has its origin in Upper India. It is almost certain there is a drift of varying intensity from the Afghan and Baluchistan plateaus down the passes which contributes towards the initiation of the current in Upper India. Information that I have received from officers serving in that frontier district shows that there are very frequently strong winds approaching in force to a gale blowing down the passes, whilst upwinds are rarely observed and are almost invariably feeble. This irregular drift down the river valleys and passes of the Sulemán mountains, cannot, however, be regarded as an integral part of a general lower air movement over Northern India. The latter may be fed to a slight extent by a flow of air across the passes and down the valleys of the great frontier ranges to the north and west of India from the area of the Central Asian anticyclone at this season of the year. But the mountain system of Northern India cuts India off entirely from any large horizontal current from the north in the lower and middle strata of the atmosphere. Hence the lower air movement in India at this season of the year is chiefly determined :—

(1) By the pressure conditions and gradients in the Indian land area and adjacent seas.

(2) By the amount of irregular drift from the north and north-west and probably chiefly down the river valleys and passes in the Sulemán Mountains.

The latter is usually small in amount, but under certain conditions may be so large as to modify the temperature and humidity conditions of Northern India to a marked extent.

The following table gives data of the mean air movement of this period in different parts of India :—

TABLE CVII.

AREA.	AVERAGE MEAN DAILY AIR MOVEMENT IN MILES			Average mean steadiness of wind during period January and February.
	January.	February.	Mean of period January and February.	
North Punjab	55	70	63	17
South Punjab	63	83	73	22
North-Western Provinces, West	66	80	73	43
Ditto ditto, East	76	99	88	32
Bihar	50	72	61	44
Bengal and Orissa, Inland	45	59	52	36
Ditto ditto, Coast	129	163	146	26
Arakan	67	85	76	45
Burma Coast	85	95	91	51
Bay Islands	195	156	176	81
Rajputana	76	91	84	16
Central India	88	103	96	26
Central Provinces	61	75	68	21
Deccan	94	105	100	25
Madras Coast East	148	144	146	65
West Coast (Bombay)	143	150	147	42

The chief inferences from the preceding are :—

(1) The air movement is feeble in Northern India, averaging about 3 miles per hour in the Punjab and increasing slightly in intensity eastwards down the Gangetic Plain.

(2) The air movement also increases southwards from the Punjab across Rajputana to Central India and the North Bombay Coast, where it averages 6 miles per hour.

(3) The air movement is moderate in amount in the east of the Peninsula and increases westwards across the Peninsula to the Sahaydri range.

(4) The air movement is moderate in amount in the west coast districts.

(5) The air movement is greater in February than in January over the whole land area except Southern India (represented by Madras and Trichinopoly). The decrease in this area is evidently a result of the increasing temperature which tends to give rise to local winds between the sea and land and also to a diminution in the general strength of the air movement in the Bay of Bengal, and of its continuation in the Peninsula.

The direction of the air movement in different parts of India and the Indian seas during this period is fully shown in Fig. 1, Plate XLVIII, which gives the mean wind directions and steadiness in January at 79 stations. The wind directions in these charts are indicated in the usual manner, and the precentage steadiness by the length of the arrows.

An examination of this chart shows that the air movement over the whole of India

with the exception of the west coast districts) is a general drift from the interior of India and across the neighbouring seas towards the equatorial belt.

The only considerable area in which the air movement is not part and parcel of this general drift is the west coast districts of the Konkan and Malabar which are cut off by the West Ghats from the general drift from north-east to south-west across the Peninsula. In that area the winds are really land and sea breezes of moderate intensity, as is shown by the following means based on hourly observations recorded at Bombay and Trivandrum for many years in January:—

Hour	Bombay.		Trivandrum.	
	Mean hourly wind velocity in miles.	Mean hourly wind direction.	Mean hourly wind velocity miles.	Mean hourly wind direction.
Midnight	7·5	N 1° W	6·9	N 41° W
1	7·3	N 4° E	6·9	N 37° W
2	7·3	N 10° E	7·8	N 21° W
3	7·5	N 13° E	8·5	N 11° W
4	8·1	N 16° E	8·8	N 6° W
5	8·5	N 23° E	9·6	N
6	8·7	N 25° E	10·5	N
7	8·9	N 34° E	9·4	N 3° E
8	8·9	N 40° E	7·1	N 7° E
9	9·0	N 42° E	5·8	N 25° E
10	9·1	N 39° E	5·6	N 5° W
11	8·2	N 25° E	6·7	S 42° W
Noon	8·3	N 14° W	9·9	S 47° W
13	10·9	N 38° W	12·8	S 43° W
14	12·8	N 45° W	13·8	S 42° W
15	14·6	N 46° W	13·5	S 45° W
16	15·8	N 42° W	11·7	S 48° W
17	16·3	N 37° W	9·4	S 49° W
18	16·0	N 33° W	5·9	S 49° W
19	15·4	N 28° W	3·1	S 49° W
20	14·8	N 26° W	2·8	S 56° W
21	12·4	N 20° W	3·6	S 66° W
22	9·6	N 13° W	5·1	S 75° W
23	8·3	N 7° W	6·6	N 51° W

The chart (Fig. 1, Plate XLVIII) also indicates that the air movement is very unsteady in Upper India and that it increases in steadiness eastwards and southwards. It is most steady in Southern India and the southern half of the Bay of Bengal and probably in the centre and south of the Arabian Sea.

It may also be noted that the wind directions of certain hill stations are given by arrows in broken lines in the same chart.

The depth of the lower air current shown by the wind directions in Fig. 11 Plate XLVIII, has not been determined by direct measurement. This lower air current is almost certainly not more than 3,000 or 4,000 feet in depth over the plains of Northern and Central India. The chief reasons for this statement are as follows:—

(1) The mean wind directions of Mount Abu, Pachmarhi and Chikalda are quite different from those at the neighbouring plains stations either to the north or south, as is at once seen by a reference to the chart, Fig. 1, Plate XLVIII. The elevations of these stations are all about 4,000 feet, *viz.*:—

Chikalda	3,656 feet.
Pachmarhi	3,528 "
Mount Abu	3,945 "

(2) The winds are remarkably unsteady and variable at these stations, more especially when contrasted with the nearest plains stations, *e.g.*—

Hill station.		Plain station.	
Chikalda .	23 per cent.	Buldana . .	26 per cent.
Pachmarhi . .	17 "	Nagpur . .	39 "
Mount Abu . .	6 "	Deesa . .	39 "

(3) The winds at the hill stations in the Himalayas are in no way related to the lower air movement of the Gangetic Plain but form an independent system

(4) The winds at Shillong and Tura for which partial data are available in the meteorological office indicate that the air movement is from southerly directions in the Assam hills (about 3,500 feet in average elevation) whilst it is from northerly directions in the Bengal plains to the south. The following gives available data:—

Station.	[illegible] Direction.	[illegible] Steadiness.	[illegible] Direction.	[illegible] Steadiness.
Tura . . .	S 4° W .	43	S 12° W	65
Shillong	S 19° W .	50	S 69° W	41

Little is known of the middle air movement during this period. The direction of movement of the cirrus clouds indicates that there is over the whole of Northern and Central India a rapid drift of the upper atmosphere from west or west-south-west. This is in accordance with theory and the results of observation in other parts of the world.

Little is known of the air circulation in the intermediate strata between those of the lower air movement (up to 4,000 feet) and of the upper air movement above 15,000 or 20,000 feet.

It is certain (as shown in my memoir on the Winds of Simla, India Meteorological Memoirs, Vol. VI, Part V.) that in the Western Himalayas there is in fine weather an alternating movement between the hills and plains, the movement being upwards during the day time and downwards in the night time in the lower strata and the opposite in the middle atmospheric strata.

The data for the Assam hill stations, as already pointed out, indicate that there is a moderately damp current from the head of the Bay immediately above the current from the north-east in Bengal.

It is probable that there is a similar drift from the Arabian Sea at the elevation of 4,000 or 5,000 feet and upwards across the Sind and Kathiawar coasts, but I have not been able to obtain any direct evidence of its existence. The diurnal variation of cloud during this period at Mount Abu is, however, slightly in favour of this supposition.

The lower air movement over Northern and Central India indicates that there is a steady outflow from these areas towards the adjacent seas. It is evident, as the air pressure remains fairly constant during the period, that the lower outflow must be compensated by an influx in the middle atmospheric strata.

The preceding remarks have indicated the probable existence of the following air movements in the middle atmospheric strata over India :—

(1) Influx from the north of the Bay of Bengal across Bengal.
(2) Influx from the north of the Arabian Sea across the Sind and Kathiawar coasts.
(3) Influx from the plateau areas to the west of the Indus Valley frontier.
(4) A balance of influx from the alternating movements of the west coast districts and of the Himalayan Mountain ranges.

It is almost certain that the movements of inflow numbered (1), (2) and (3) are of much greater volume and intensity, and hence of greater importance, than has hitherto been assumed by Indian meteorologists.

It may here be noted that at Maymyo, the only hill station in Burma for which data are available, the mean wind direction is S. 55° W. in January and February, whilst in the plains at Mandalay at a distance of less than 25 miles in a direct line, the mean winds are from N. 21°E. Hence it is probable that the drift from the north in the river valleys of Burma is comparatively shallow, and that there is an inflow from south at a moderate elevation.

The only large and important abnormal features of the air movement super-imposed at intervals during the period upon the normal movement are associated with the movement of cold weather storms or cyclonic disturbances.

These are extensive shallow depressions which, in the majority of cases, form in the plateau of Iran, and advance in directions ranging between east and east-south-east across Baluchistan and Northern India. The whole of the evidence, including that of direct measurement of the height of the clouds, indicates that these storms are of very considerable elevation, the field of condensation and rain formation being at an elevation of 15,000 feet to 25,000 feet. The air movement is hence usually feeble to moderate at the level of the plains, but is very vigorous on the middle and higher elevations of the Himalayas. The advance of the storms across Northern India gives rise to the normal cyclonic shift of winds with the corresponding changes of temperature, humidity and cloud. The most noteworthy feature in connection with these storms is the strong westerly winds which prevail for some days in their rear. These winds are remarkable for their low temperature as well as great dryness. They are hence not due to a downflow in the retreating semi-circle or quadrant of the cyclonic storms.

The only satisfactory explanation of the characteristic features of these winds is that they are due to a vigorous inflow from the plateau areas to the north-west of India. Their temperature is directly related to the extent of the snow-clad surface and the elevation of the snow-line. The advance of these winds with their accompanying temperature and humidity conditions has been traced on several occasions from Southern Russia across Persia, Baluchistan and Northern India at a fairly uniform rate, approximately the same as that of the storms marching in front of them. The intensity of these features

differs very considerably in different storms. When they are most pronounced they affect the hill stations in Central India and the North Deccan and the coast stations of the Konkan almost as strikingly as the stations in the plains of Northern India. It is hence very probable that this outflow from Baluchistan across Northern India and the North-East Arabian Sea is of considerably greater depth than the ordinary drift in fine weather. There is not sufficient evidence to enable an estimate to be formed, but it probably reaches up to an elevation of at least 6,000 feet.

(1) Diurnal variation of the velocity of the lower air movement.—Over the whole of the plains of India, there is a well-marked diurnal variation in the air movement during the cold weather period. The air movement is usually feeblest during the night hours (about midnight) and increases rapidly from about 8 A.M. to 2 P.M., when the velocity is from two to four times as great on the average as it is during the night hours. It falls off rather rapidly from 3 P.M. or 4 P.M. to 8 P.M., and is feeble during the night hours, when calms and light unsteady airs, as a rule, obtain.

The following gives the maximum and minimum velocity and their epochs at representative stations for which data are available:—

Station.	Mean hourly air movement in miles during the season, October to February.		Epoch.	
	Minimum.	Maximum.	Minimum.	Maximum.
Lahore	0·6	2·7	3 and 4 A.M.	4 P.M.
Agra	2·0	5·5	11 P.M.	2 P.M.
Lucknow	2·1	5·2	7 and 8 A.M. and P.M.	2 P.M.
Allahabad	3·5	9·1	6, 10 and 11 P.M.	2 P.M.
Jaipur	2·7	6·2	8 A.M.	1 P.M.
Patna	1·5	2·6	10 P.M. to 3 A.M.	2 P.M.
Hazaribagh	3·2	8·9	11 P.M. and midnight	3 P.M.
Jubbulpore	0·9	3·4	2 and 3 A.M.	2 and 3 P.M.
Nagpur	2·2	5·1	10 and 11 P.M.	2 P.M.
Bellary	1·7	5·8	Midnight to 3 A.M.	2 P.M.
Trichinopoly	2·7	5·5	3 and 4 A.M.	2 and 3 P.M.
Pachmarhi	1·3	5·4	2 A.M.	2 P.M.

The epochs of the maximum and minimum are apparently abnormal and unique at the following stations:—

Station.	Mean hourly air movement in miles during the season, October to February.		Epoch.	
	Minimum.	Maximum.	Minimum.	Maximum.
Poona	2·5	10·2	7 A.M.	7 P.M.
Belgaum	2·1	4·0	1 to 3 A.M.	12 A.M. to 2 P.M.
Rangoon	2·6	5·8	9 and 10 P.M.	10 and 11 A.M.
Deesa	5·6	8·5	1 and 2 P.M.	Midnight.

The data of Pachmarhi show that the variation of the air movement is similar in character to that of the level of the plains. On the other hand, the Simla wind observations (recorded by a Beckley's anemograph) indicate that the air movement over the Western Himalayas has a double oscillation during the course of the 24 hours.

The following table gives mean hourly data of the wind velocity for the month of February at stations in the Gangetic Plain at which hourly readings of the anemometer have been recorded during recent years:—

TABLE CVIII.—*Mean hourly velocity of the wind in February at seven typical stations in Northern India.*

Hour.	Lahore.	Roorkee.	Jaipur.	Lucknow.	Allahabad.	Patna.	Hazaribagh.
Midnight	1·3	1·4	4·2	3·6	5·3	1·9	3·3
1	0·9	1·5	4·5	3·5	5·0	1·9	4·4
2	1·0	1·5	4·7	3·5	5·0	2·0	4·4
3	1·0	1·4	4·4	3·4	4·9	2·0	4·6
4	1·0	1·4	4·4	3·3	4·8	2·2	4·7
5	1·8	1·4	4·2	3·4	4·9	2·3	4·1
6	1·8	1·4	3·5	3·4	5·2	2·3	4·3
7	1·8	1·3	3·7	3·2	5·1	2·8	4·2
8	1·9	1·5	3·1	3·3	6·0	2·8	4·9
9	2·8	1·6	3·8	4·2	8·0	2·8	7·4
10	2·9	2·0	5·8	5·0	8·7	3·6	9·1
11	2·9	2·9	5·6	6·2	10·0	3·6	9·9
Noon	2·9	3·7	6·6	7·1	11·0	3·7	9·7
13	3·6	4·1	7·4	7·1	11·8	4·0	10·6
14	3·6	4·5	7·2	7·5	12·1	4·0	10·9
15	3·6	4·7	7·2	7·6	11·8	4·0	11·5
16	3·5	4·6	7·2	6·9	10·4	2·9	10·9
17	1·9	3·9	7·0	5·4	6·8	2·9	9·6
18	1·8	2·7	4·8	3·7	4·9	2·9	7·2
19	1·8	2·2	3·8	3·0	4·9	2·0	4·8
20	1·8	2·3	2·7	3·1	5·0	2·0	4·3
21	1·4	2·0	3·0	3·4	5·1	2·0	4·5
22	1·4	1·8	3·4	3·6	5·0	1·9	3·9
23	1·3	1·5	3·9	3·5	5·1	1·9	3·5

The following table gives mean hourly directions of the wind for the same stations in the Gangetic Plain :—

TABLE CIX.—*Average mean wind direction and percentage steadiness of wind in February at seven typical stations in Northern India.*

Hour.	Lahore.		Roorkee.		Jaipur.		Lucknow.		Allahabad.		Patna.		Hazaribagh.	
	Steadiness.	Direction.	Steadiness.	Direction.	Steadiness.	Direction.	Steadiness.	Direction.	Steadiness.	Direction.	Steadiness.	Direction.	Steadiness.	Direction.
	%		%		%		%		%		%		%	
Midnight.	23	N 12° W	24	N 75° W	51	N 27° W	33	N 50° W	15	N 32° W	50	N 83° W	51	N 74° W
1	29	N 17° W	21	N 85° W	48	N 21° W	33	N 51° W	18	N 51° W	48	S 86° W	61	N 70° W
2	21	N 22° W	13	N 80° W	47	N 17° W	33	N 50° W	20	N 44° W	48	S 85° W	55	N 73° W
3	21	N 15° W	8	S 81° W	47	N 13° W	35	N 49° W	20	N 65° W	48	S 81° W	51	N 76° W
4	21	N 2° E	10	S 79° W	52	N 6° W	38	N 46° W	20	N 62° W	50	S 77° W	57	N 84° W
5	15	N 9° E	3	N 47° W	47	N 3° W	40	N 39° W	23	N 46° W	40	S 67° W	49	S 89° W
6	17	N 3° E	13	N 73° W	42	N 4° E	34	N 41° W	23	N 50° W	44	S 72° W	47	S 82° W
7	21	N 22° W	21	N 68° W	45	N 6° W	35	N 42° W	18	N 80° W	56	S 68° W	47	N 78° W
8	25	N 40° W	10	N 58° W	31	N 13° E	35	N 42° W	25	N 76° W	62	S 67° W	41	S 89° W
9	37	N 27° W	5	S 58° W	41	N 16° E	40	N 29° W	35	N 66° W	54	S 72° W	45	N 79° W
10	31	N 28° W	13	S 10° E	23	N 10° E	43	N 33° W	30	S 84° W	56	S 81° W	51	N 82° W
11	38	N 63° W	23	S 57° W	20	N 40° W	45	N 35° W	33	N 73° W	60	S 83° W	59	N 83° W
Noon.	45	N 53° W	38	S 76° W	27	N 56° W	40	N 50° W	35	N 60° W	50	N 84° W	67	N 78° W
13	44	N 50° W	38	N 88° W	39	N 60° W	33	N 57° W	45	N 60° W	58	N 81° W	79	N 68° W
14	48	N 59° W	45	S 84° W	45	N 65° W	33	N 54° W	45	N 46° W	65	N 85° W	81	N 63° W
15	54	N 57° W	38	N 86° W	48	N 71° W	35	N 57° W	48	N 40° W	65	N 86° W	77	N 59° W
16	46	N 54° W	38	N 68° W	52	N 60° W	35	N 56° W	43	N 47° W	70	N 82° W	79	N 59° W
17	33	N 51° W	43	N 77° W	53	N 56° W	35	N 39° W	38	N 37° W	65	N 79° W	87	N 59° W
18	10	N 37° W	41	N 69° W	44	N 47° W	35	N 47° W	10	N 46° W	60	N 78° W	83	N 53° W
19	17	N 39° W	30	N 77° W	47	N 55° W	33	N 51° W	8	N 80° W	56	N 83° W	69	N 56° W
20	19	N 3° W	35	S 67° W	47	N 56° W	33	N 52° W	8	N 80° W	54	N 82° W	65	N 53° W
21	16	N 2° W	25	N 76° W	44	N 54° W	33	N 53° W	10	S 78° W	52	N 80° W	57	N 62° W
22	21	N 4° E	18	S 81° W	42	N 36° W	33	N 48° W	10	N 73° W	54	N 87° W	45	N 68° W
23	17	N 16° W	28	N 81° W	45	N 31° W	33	N 53° W	10	N 44° W	48	N 82° W	49	N 70° W

The following is a summary of the more important inferences from the preceding data :—

(1) The air movement is characterized by great unsteadiness during the night hours at these stations and more especially at Lahore, Roorkee and Allahabad.

(2) In the Gangetic Plain winds increase in steadiness eastwards and are steadiest between 1 P.M. and 4 P.M. at the western stations and between 1 P.M. and 6 P.M. at the eastern stations.

(3) At Lahore, Jaipur, Lucknow and Allahabad the mean winds are on the whole slightly more westerly and less northerly during the day hours and slightly more northerly and less westerly during the night hours than the mean.

(4) At Patna and to a less extent Hazaribagh winds are nearly due west. There is a slight northerly component during the day hours and a feeble southerly component in the early morning hours.

(2) *Diurnal variation of the direction of the lower air movement.*—There is slight to moderate shift of wind during the day at all these stations in the interior of India. The following gives a summary of its chief features in different parts of India.

The diurnal variation of the direction of the air movement is given by curves plotted from the data in the original memoirs. These curves for the cold weather season are generally elongated curves—the longer axis of which is usually nearly parallel to the mean direction of the winds. The following table furnishes data giving the direction of the axes of these curves and the actual hours corresponding to the extremities of the axes during the cold weather season, October to February, for twelve stations in different parts of India :—

Station	Direction of the axis	Actual hours corresponding to the extremity of the axis in	
		Morning.	Evening
Lahore	ESE to WNW	4 A.M.	2 P.M.
Roorkee	ESE to WNW	9 „	4 „
Lucknow	SSE to NNW	Midnight	Noon.
Allahabad	SSE to NNW	8 P.M.	3 P.M.
Jaipur	ENE to WSW	8 A.M.	2 „
Patna	SSE to NNW	7 „	4 „
Hazaribagh	S to N	7 „	5 „
Jubbulpore	SSE to NNW	5 „	2 „
Nagpur	NW to SE	6 „	Noon.
Bellary	W to E	6 „	11 A.M.
Trichinopoly	WNW to ESE	8 „	6 P.M.
Pachmarhi	SSE to NNW	8 „	4 „

The chief effect of the diurnal variation at stations in the Gangetic Plain is to strengthen the air movement during the day hours, but to give little change of direction. The northerly and westerly components are hence much strengthened during the day hours, whilst at night these components tend to become unsteady and are, more especially at the more westerly stations, including Lahore and Roorkee, replaced by feeble airs from easterly directions and occasionally from southerly directions. The general tendency to increased steadiness and strength of movement from the normal direction during the day hours is shown as clearly at the easterly as at the westerly stations. The curves giving the

diurnal rotation or variation for stations in the Gangetic Plain hence form irregular elongated figures, the axes of which are approximately parallel to the mean direction, and the left hand or westerly halves of the curves correspond to the day hours and the easterly halves to the night hours.

There are two areas in which the local conditions cause a complete reversal of the wind direction from day to night, and in which it is hence different in character to the preceding. The first includes the stations of Jubbulpore, Pachmarhi and Nagpur. At Jubbulpore and Pachmarhi the air movement is from northerly directions during the day and from southerly directions during part of the night, whereas at Nagpur the opposite is the case. The axes of the representative curves are hence not parallel to the mean wind direction but are at right angles to the ranges of the Vindhyas and Satpuras which form a broad mountain belt across the head of the Peninsula.

The following gives mean hourly data for these three stations in January:—

Hour.	Jubbulpore.	Pachmarhi.	Nagpur.
Midnight.	S 43° E	S 38° W	N 33° E
1	S 77° E	S 85° W	N 36° E
2	S 48° E	S 69° W	N 29° E
3	S 64° E	S 74° W	N 22° E
4	S 70° E	S 45° W	N 8° E
5	S 83° E	S 37° W	N 12° E
6	S 73° E	S 37° W	N 8° E
7	S 43° E	S 47° W	N 10° E
8	S 33° E	S 22° W	N 11° E
9	S 31° E	S 14° W	N 32° E
10	S 29° E	N 32° W	N 57° E
11	S 63° W	S 56° W	S 78° E
Noon	N 2° W	N 84° W	S 63° E
13	N 31° W	N 78° W	S 18° E
14	N 42° W	N 47° W	S 33° E
15	N 21° W	N 44° W	S 35° W
16	N 20° W	N 29° W	S 13° W
17	N 4° E	N 25° W	S 36° E
18	N 42° E	N 25° W	S 11° E
19	N 68° E	N 54° W	S 59° E
20	N 61° E	N 67° W	S 54° E
21	N 80° E	S 31° W	N 87° E
22	N 39° E	S 70° W	N 37° E
23	N 29° E	S 81° W	N 10° E

Again, at most of the coast stations, including Chittagong, Bombay, Trivandrum and Kurrachee, there is a complete shift of wind from easterly to westerly directions, and *vice versâ*, during the day due to the alternating influence of the land and sea breezes.

The following gives mean hourly wind directions of these stations for January:—

Hour.	Average mean hourly direction of wind in January at			
	Chittagong.	Bombay.	Trivandrum.	Kurrachee.
Midnight	N 8° W	N 1° W	N 41° W	N 17° W
1	N 12° W	N 4° E	N 37° W	N 2° W
2	N 3° W	N 10° E	N 21° W	N 7° W
3	N 1° W	N 13° E	N 11° W	N 3° E
4	N 13° E	N 16° E	N 6° W	N 9° E
5	N 15° E	N 23° E	N	N 10° E
6	N 10° E	N 25° E	N	N 11° E
7	N 15° E	N 34° E	N 3° E	N 10° E
8	N 14° E	N 40° E	N 7° E	N 18° E
9	N 24° E	N 42° E	N 25° E	N 18° E
10	N 35° E	N 39° E	N 5° W	N 12° E
11	N 31° E	N 25° E	S 42° W	N 1° W
Noon	N 4° E	N 14° W	S 47° W	N 3° W
13	N 65° W	N 38° W	S 43° W	S 10° E
14	N 81° W	N 45° W	S 42° W	S 32° W
15	S 83° W	N 46° W	S 45° W	S 64° W
16	W	N 42° W	S 48° W	S 63° W
17	N 82° W	N 37° W	S 49° W	S 68° W
18	N 69° W	N 33° W	S 49° W	S 70° W
19	N 61° W	N 28° W	S 49° W	S 83° W
20	N 60° W	N 26° W	S 56° W	N 63° W
21	N 41° W	N 20° W	S 66° W	N 68° W
22	N 38° W	N 13° W	S 75° W	N 45° W
23	N 25° W	N 7° W	N 51° W	N 37° W

The diurnal variation in Assam conforms to the general rule that in the day hours winds from the normal direction (north-east) are considerably strengthened, whilst at night they are much less steady and are occasionally replaced by westerly winds (with some southing).

The diurnal rotation at stations in the open Deccan, including Poona, Belgaum and

Bellary, conforms to the same rule. The mean winds are from east-north-east. In the day time winds are strengthened from the east and north, whereas at night they are weaker and much less steady and occasionally give way to light airs from west and south.

The following gives mean wind directions for each hour of the mean day in January and February at these Deccan stations:—

Hour.	Average mean direction of wind in January and February at					
	Poona.		Belgaum.		Bellary.	
	January.	February.	January.	February.	January.	February.
Midnight . .	N 36° W	N 69° W	N 37° E	S 77° W	S 66° E	S 37° E
1 . .	N 53° W	N 74° W	N 15° E	S 89° W	S 66° E	S 41° E
2 . .	N 48° W	N 76° W	N 24° E	N 80 W	S 80° E	S 43° E
3 . .	N 54° W	N 76° W	N 45° E	N 71° W	S 88° E	S 28° E
4 . .	N 37° W	N 77° W	N 51° E	N 63° W	S 57° E	S 56° E
5 . .	N 50 W	N 78° W	N 50° E	N 44° W	S 63° E	S 47° E
6 . .	N 43° W	N 81° W	N 57° E	N 1° E	S 83° E	S 38° E
7 . .	N 41° W	N 87° W	N 56° E	N 26° E	S 82° E	S 30° E
8 . .	N 66° W	N 89° W	N 69° E	N 73° E	S 64° E	S 20° E
9 . .	N 16° W	N 73° W	N 88° E	N 80° E	S 62° E	S 40° E
10 . .	N 60° E	N 16° E	N 83° E	S 82° E	S 62° E	S 57° E
11 . .	S 72° E	S 55° E	S 89° E	S 77° E	S 73° E	S 63° E
Noon . .	S 83° E	S 9° E	N 83° E	S 73° E	S 76° E	S 63° E
13 . .	S 87° E	S 74° W	N 88° E	S 43° E	S 60° E	S 65° E
14 . .	S 43° E	S 67° W	S 76° E	S 11° E	S 74° E	S 78° E
15 . .	S 7° E	N 87° W	N 85° E	S 7° W	S 76° E	S 54° E
16 . .	W	S 87° W	N 75° E	S 27° W	N 85° E	S 67° E
17 . .	E	S 80° W	N 80° E	S 34° W	N 86° E	S 74° E
18 . .	N 42° W	N 52° W	S 63° E	S 69° W	N 81° E	S 87° E
19 . .	N 45° W	N 49° W	S 56° E	S 68° W	S 73° E	S 60° E
20 . .	N 68° W	N 64° W	S 62° W	S 70° W	S 66° E	S 76° E
21 . .	N 53° W	N 65° W	S 74° W	S 69° W	S 74° E	S 70° E
22 . .	N 64° W	N 63° W	N 34° W	S 69° W	S 74° E	S 59° E
23 . .	N 54° W	N 62° W	N 19° W	S 75° W	S 72° E	S 64° E

Hot weather air movement in India.—The air movement in India during this period is much more complicated than that of the preceding period. In the Indian seas away from the land light to moderate north-east or variable winds prevail

during the period, but increase in intensity and steadiness, as is roughly shewn by the following mean data for the central areas of the Bay of Bengal and Arabian Sea:—

Month.	Mean daily force of wind. (Beaufort notation.)	
	Bay of Bengal. (Area between Lat. 4° N. and 16° N. and Long. 84° and 91° E.)	Arabian Sea. (Area between Lat. 4° N. and 16° N. and Long. 58° and 70° E.)
March	2·5	2·6
April	2·7	2·7
May	3·5	3·0

This increase in intensity with the advance of the season is probably mainly due to the increasing temperature in India, Arabia and Africa, more especially when compared with the neighbouring seas. This action undoubtedly gives rise to very strong winds in the neighbourhood of the Indian coasts, and it is probable that the general increase of temperature over the whole monsoon area gives rise to a more or less general increase of the air movement over the whole sea and land areas.

The air movement in India during the hot weather tends to become more and more local in character and more dependent upon the thermal conditions in India and upon actions set up by these conditions. It is not an integral part of a general air movement in Southern or Central Asia, nor is it any longer the origin and earlier part of the horizontal *movement of the north-east monsoon which continues in the open over the central part of* the Indian seas. The actions determining these modifications or changes of the air movements depend mainly on the thermal conditions in India and their relations to those of the neighbouring sea areas.

The hottest area in March is defined by the isotherm of 85°, and includes the Central and South Deccan and Mysore. In April, it is defined by the isotherm of 90° and includes the Deccan and the Central Provinces south of the Satpura and Sahyadri ranges. In May the mean temperature exceeds 90° over nearly the whole of the interior. It is over 95° in a portion of Rajputana and Central India, which hence define the hottest area. The chief feature of the temperature conditions of May is the almost uniform high temperature over nearly the whole of the interior of Northern and Central India (excluding Bengal and the submontane districts).

The following gives approximately the mean temperature conditions in the hottest areas in each month and the corresponding data for the adjacent sea areas:—

March.

Hottest area.	Temperature reduced to sea-level.		
	Mean maximum.	Mean minimum.	Mean temperature.
	°	°	°
Land area (Central Provinces South, Deccan and Mysore)	101·9	72·3	86·0
Arabian Sea area (between Long. 70° E and Bombay Coast .	83·5	80·1	81·8
Difference	+18·4	—7·8	+4·2

APRIL.

Hottest area.	Temperature reduced to sea-level.		
	Mean maximum.	Mean minimum.	Mean temperature.
	°	°	°
Land area (Central Provinces South and Deccan) . .	107·3	78·4	92·2
Sea area (between Long. 70° E and Bombay Coast) .	84·8	81·7	83·1
Difference	+22·5	−3·3	+9·1

MAY.

Hottest area.	Temperature reduced to sea-level.		
	Mean maximum.	Mean minimum.	Mean temperature.
	°	°	°
Land area (Rajputana and Central India)	108·0	82·8	94·9
Sea area (between Lat. 20° N and 25° N and Long. 60° E and 70° E).	83·7	80·5	82·1
Difference	+24·3	+2·3	+12·8

The preceding data indicate that during the day hours in the months of March, April and May, the atmosphere over the interior of India is heated from 15° to 25° above the neighbouring seas, and occasionally as much as 30° or 35°.

During the night hours the temperature in March falls considerably and in April slightly below that of the neighbouring seas. In the month of May the interior heated land area is, both by day and night, on the average at a higher temperature than the neighbouring seas.

In the plains of Northern India there is a special action due to the fact that the eastern districts (Bihar and Bengal) are ten to fifteen degrees further east than the western districts, in consequence of which the heating action due to solar radiation is nearly an hour in advance in those areas than over the Punjab and western districts of the North-Western Provinces. This gives rise during the morning hours from 7 A.M. to 11 A.M. when temperature is increasing rapidly, to considerable or large thermal gradients, and hence to a rapid strengthening of the westerly winds down the Gangetic Plain. During the earlier part of the day considerable temperature gradients obtain from east to west and in the afternoon and evening slight thermal gradients usually obtain in the same direction, but are occasionally reversed in directions, conditions which are not disclosed when only mean temperature data are considered. For further information see paper on "The hot winds in Northern India," Indian Meteorological Memoirs, Vol. VI, Part III.

In the Indo-Gangetic Plain, west of Bihar, there is little change in the direction of the mean air movement during this period. North-west to west winds obtain very steadily throughout the whole period. In Rajputana, Central India and the northern

districts of the Central Provinces winds shift to some extent and become more westerly throughout the season, so that in April and May there is a strong drift from a westerly direction across the whole of Central and Northern India west of Long. 84° to 86° E.

This movement is usually feeble during the night hours. It increases rapidly from about 8 A.M. to noon and is very vigorous from about 11 A.M. to 4 P.M. or 5 P.M., the intensity directly depending upon the temperature conditions and gradients.

There is also during this period a strong and increasing indraught to the heated interior across the sea coasts of Cutch and Kathiawar. The mean winds in these areas in April and May are almost due west. This movement forms an integral and important part of the general air movement across Northern and Central India from west to east during this period. The strength of this local indraught is indicated by the following data :—

Station.	Average wind velocity in miles per diem.		
	March.	April.	May.
Bhuj	198	261	370
Rajkot	195	248	323

The air movement is very complicated in North Eastern India. There is a large and increasing influx of air across the Bengal Coast from the head of the Bay, similar in origin and character to the movement across Cutch and Kathiawar. There is also a strong and increasing flow down the Assam Valley and across North Bengal. The easterly air movement down the Gangetic Plain is directly continued across South Bihar and Chota Nagpur. This system of wind tends to give a *quasi*-permanent irregular cyclonic circulation about an area usually comprising Central and South Bihar and the adjacent districts of Chota Nagpur. The interaction of these winds or currents of very different hygrometric conditions gives rise to frequent thunderstorms and hailstorms and occasionally to tornadoes, their frequency and the amount of the accompanying precipitation increasing as a whole from March to April or May. These storms chiefly occur in the areas towards which the local sea winds are determined, *viz.*, Assam, East and North Bengal.

The air movement in the Peninsula is also somewhat complicated. The coast districts in the southern half are flat and open, and the ground rises gradually to the plateau in the interior. On the other hand, the narrow west coast districts are shut off to some extent by the high wall of the West Ghâts.

In March and April there is a marked tendency to a stationary and irregular cyclonic circulation over the hot area in the Deccan. South to south-east winds prevail in the Madras coast districts, northerly to westerly winds in the Konkan and at Sholapur, Poona and Belgaum, and south-west winds at Bellary and Bangalore. This circulation disappears in May when the hottest area is transferred northwards into Rajputana, and west winds prevail in the Deccan as well as in the Konkan and Malabar. Hence the general direction

of the air movement over by far the greater part of India (except the Punjab and North-Western Provinces) in May is similar to, and almost identical in direction with, that which obtains during the next period (*viz.* the south-west monsoon).

During the cold-weather period the winds and air movement in the coast districts (except in the west coast districts from Bombay southwards) form part of the general cold weather outflow from the interior of India to the adjacent seas. This circulation usually continues unchanged in all its more important features until about the third or fourth week of February, when feeble sea winds usually commence in a very narrow belt of the coast districts of Burma, Bengal, Sind and Kathiawar. They increase in intensity and extend landwards and seawards during the next two months, and are in the month of May frequently of great intensity, blowing occasionally with a velocity of 25 to 40 miles an hour at the coast stations of Saugor Island, False Point, Bhuj and Veraval. They extend seawards to a distance of 200 to 300 miles from the coast in the Arabian Sea during the month of May. In the Bay of Bengal similar sea winds prevail off the Madras Coast to a considerable distance and also over the whole of the Bay north of Lat. 16° N. It should, however, be carefully noted that these sea winds are throughout the period local winds and are not part of a large general air circulation over the whole of the Indian Seas. They are merely the increasing local indraught into India due to the increasing intensity of the thermal conditions in the interior and do not extend to any considerable distance seawards from the coast districts.

The preceding remarks have indicated fully the chief features of the normal air movement in India during the hot weather. They may be summarized as follows:—

(1) There is a strong and increasing flow during this period from the west or north-west from the Punjab down the Gangetic Valley and from the Sind and Kathiawar coasts across Rajputana, Central India, Berar and the Central Provinces. The increase is marked in the month of May over Rajputana, Central India, the Central Provinces and Berar, where it is more pronounced than in the Gangetic Plain.

(2) There is a steady westerly inflow from the east of the Arabian Sea across the Konkan and Malabar coasts, the influence of which extends further eastwards with the advance of the season.

(3) There is a steady influx from the south of the Bay across the Coromandel and South India coasts. The winds on these coasts are on the mean of the period from south-east.

(4) The winds are very variable and unsteady in the Deccan area between the two belts in the west and east of the Peninsula over which sea winds from the Arabian Sea and from the south of the Bay prevail almost exclusively. Winds are unsteady over the whole Deccan area south of Berar and the Central Provinces in March and April, and also in the eastern half of that area in May, steady westerly winds extending from the West Coast over the western half in that month.

(5) There is a strong influx of sea winds across the Bengal coast during the period, usually most vigorous in April.

(6) There is a moderate and fairly steady downflow of air in the Assam Valley.

(7) The three systems of converging winds in North-Eastern India (*viz.*, of southerly winds in South and East Bengal, easterly winds down the Assam Valley and north-westerly to westerly winds in the eastern districts of the North-Western Provinces and Chota Nagpur) give rise to a *quasi*-permanent, unsteady cyclonic air movement over North-Eastern India the centre of which is usually in South Bihar or Chota Nagpur.

(8) There is a strong influx of sea winds across the South Burma or Pegu coast in April and May. Southerly winds, the continuation of these sea winds, prevail in increasing strength in the interior of Burma during the period.

(9) A special feature of the air movement in North-Western India is the marked tendency to the establishment of a local cyclonic circulation in the Sind hot area. It is shown clearly in the wind charts (Fig. 3, Plate XLVIII) by the wind directions at Kurrachee, Mooltan and Jacobabad. (It may be noted that this low pressure in the Sind hot area is not a permanent feature until the month of June.)

The more important features of the mean air movement in India during the months of March and May will be seen at a glance on reference to Figs. 2 and 3, Plate XLVIII.

In the hot weather months low pressure areas form at frequent intervals in Sind or the South-West Punjab. Usually after two or three days' incubation they move eastwards across Upper India, giving duststorms in the plains and thunderstorms in the hills.

The preceding remarks give the normal features of the lower air movement.

The observations of the higher cirrus clouds show that the movement of the upper atmospheric strata is in the same general direction as in the preceding season.

Little or nothing is known by direct observation of the movement of the middle or intermediate atmospheric strata. The preceding data show that there is a steady and large inflow of air into India across the sea coasts during the period. The wind observations at Simla and general information indicate that there is also a considerable influx from the hill areas to the north and probably from the north-west of Upper India.

As pressure decreases largely over the Indian land area, it is evident that there must be a large outflow in the middle atmospheric strata to counterbalance the inflow across the coasts and to give rise to the large decrease of pressure in Northern India (averaging three-tenths of an inch), equivalent to a removal of about $\frac{1}{100}$th of the total air mass over that area.

So far as I can judge from very feeble indications there is a fairly steady drift to the south, and hence also (due to the earth's rotation) to the west from the interior of India to the seas to the south of India, and perhaps as far as the northern half of the Indian Ocean. This current is mainly fed and maintained by the very large convective air movement over India during the day hours, and to which, so far as is indicated by observations, there is little corresponding downflow in the Indian land area.

The following are the chief facts that I can bring forward in support of these statements:—

(1) Marked tendency to high pressure conditions in April and to a less extent in May in the centre of the Arabian Sea, with light anti-cyclonic winds. This is very clearly shown by the April chart of the Arabian Sea in Mr. Dallas's

weather charts of the Arabian Sea published by the India Meteorological Department.

(2) Slight tendency to similar conditions in the centre of the Bay of Bengal.

Occasionally in April and in May there occurs a large general reduction of pressure, establishing for a short period very low pressure conditions and accompanying a strong development of the hot winds of the Gangetic Plain. This is followed by an equally large and rapid increase of pressure. As an example may be given the period of the 12th to the 14th May 1894. The only apparent explanation of this is that during the first stage of this oscillatory action, the outflow in the middle atmospheric strata described above is temporarily much increased and exceeds the inflow in the lower strata, and that the opposite is the case in the second stage.

The chief abnormal features of the air movement during this period are due to the following actions :—

(1) The very occasional formation of cyclonic storms in the Bay of Bengal and Arabian Sea during the months of April and May. These march in very different directions according to the pressure and other conditions obtaining at the time of their inception.

(2) The frequent formation of shallow depressions in Sind and their march through Rajputana to the Punjab hills.

(3) *The frequent occurrence of very strong hot dry winds in the Gangetic Plain.* The air movement in that area during this period is chiefly a day movement having its maximum intensity about 3 P.M. Under circumstances and conditions which have been fully explained in the memoir, *Vol. VI, Part IV*, Indian Meteorological Memoirs, these day winds have occasionally an abnormal development and blow with the force of a gale and are characterized by intense dryness and very high temperature.

It may also be noted that the period is characterized by the frequent occurrence of hot weather storms, including tornadoes, hailstorms, thunderstorms, duststorms, etc., and that these are generally accompanied by strong to destructive winds. They occur chiefly in—

(1) Assam and East Bengal where there is much forced ascent of the sea winds blowing against and across the Assam hills.

(2) Chota Nagpur and West Bengal or in the central area of the hot weather depression in North-Eastern India.

(3) The Deccan, in the area of variable winds described in pages 216-17.

(4) Upper India, accompanying the passage of depressions from Sind eastwards across North-Western India.

The winds at all the hill stations in Central India, including Mount Abu, Pachmarhi and Chikalda, have the same general direction and are of similar steadiness to those at the neighbouring plains stations. On the other hand, the winds at Wellington and Newera Eliya differ to some extent in direction from those at the neighbouring low level stations. These facts indicate that the lower air movement extends upwards to at least 5,000 feet or 6,000 feet, and probably considerably higher. The return movement described above hence probably occurs between 10,000 feet and 20,000 feet.

The following table gives wind data for the months of March, April and May at these hill stations and the neighbouring plains stations :—

Station.	March.		April.		May.	
	Direction.	Percentage steadiness.	Direction.	Percentage steadiness.	Direction.	Percentage steadiness.
Jubbulpore	N 70° W	23	N 71° W	34	N 69° W	48
Hoshangabad	N 60° W	12	S 89° W	30	S 87° W	59
Pachmarhi (Hill)	N 57° W	32	N 62° W	43	N 66° W	58
Nagpur	N 1° E	12	N 65° W	22	N 4° W	41
Chikalda (Hill)	N 53° W	30	N 47° W	40	N 36° W	65
Buldana	N 28° W	47	N 33° W	58	N 49° W	69
Deesa	N 66° W	35	S 88° W	57	S 60° W	63
Mount Abu (Hill)	N 81° W	38	S 87° W	56	S 67° W	71
Mysore	N 84° E	37	S 79° E	2	S 83° W	64
Wellington (Hill)	S 49° E	65	S 58° E	61	N 87° E	19
Coimbatore	S 76° E	53	S 21° E	53	S 17° W	69
Colombo	N 85° W	51	S 67° W	62	S 54° W	75
Newera Eliya (Hill)	S 56° E	57	S 48° E	13	N 74° W	33

The following gives comparative data of the mean daily air movement in different parts of India during this period :—

Political division or area.	Mean daily air movement in miles.			Average mean steadiness of wind during period, March to May.
	March.	April.	May.	
				%
Punjab	59	67	71	24
North-Western Provinces and Oudh	88	95	102	32
Bihar	91	109	114	37
Chota Nagpur	194	216	222	38
Bengal and Orissa Inland	92	136	140	51
Do. do. Coast	235	308	294	56
Assam	97	120	106	30
Burma	105	117	110	50
Bay Islands	122	112	159	49
Rajputana	112	131	193	44
Central India	115	137	169	46
Central Provinces	87	106	140	35
Berar	140	163	223	49
Bombay or West Coast	167	169	199	64
Deccan	119	137	183	31
Madras or East Coast	168	211	227	72
Madras Inland	110	116	156	46

The more important inferences from the preceding are :—

(1) The air movement increases considerably in intensity from March to May. The increase is most marked in Assam, Bengal, Bihar and Chota Nagpur in April, and in the Peninsula, Berar, the Central Provinces, Central India and Rajputána in May.

(2) The air movement in April and May is greater in amount in Northern India than during the height of the monsoon (June to August).

(3) The air movement in the west coast and in the Deccan is less vigorous in the hot weather season than during the height of the south-west monsoon (June to August).

Hence the general conclusion that in the part of India dominated by the Bay monsoon current, the air movement is less in amount during the monsoon than in the two hot weather months antecedent to the monsoon, whereas in the part of India dominated by the Bombay current, the strongest winds are due to monsoon conditions and not to hot weather conditions in India. The conclusion is one of some considerable importance in dealing with the origin and character of the air motion over India generally. The following gives data in corroboration :—

Station.	Normal daily velocity of air movement in miles.				
	April.	May.	June.	July.	August.
Saugor Island	419	394	372	357	315
False Point	341	338	303	277	238
Narayanganj	171	157	178	182	162
Kurrachee	329	407	423	415	397
Bhuj	261	370	386	399	356
Rajkot	248	323	348	348	278
Deesa	228	325	397	351	278
Mount Abu	193	247	254	278	254
Bombay	264	247	376	450	376
Belgaum	320	424	556	647	517

(1) *Diurnal variation of the intensity of the lower air movement* (*vide* Figs. 9 to 16, Plate LIII, and Figs. 8 to 14, Plate LIV).—The diurnal variation is strongly pronounced in this season. It is on the whole most marked in the west coast districts and the West Deccan as represented by the stations of Bombay, Belgaum and Poona. At Bombay the velocity is least at 7 A.M. and thence increases until 3 P.M., and is practically constant until 5 P.M. It falls off rapidly until 8 P.M. and slowly during the remainder of the night.

The air movement is least at Poona at 7 A.M. It thence rises rather quickly until 11 A.M. when there is a slight lag lasting until nearly 1 P.M. The movement thence increases rapidly until 7 P.M. (when it is four times as great as at 7 A.M.). It thence decreases at first rapidly until about midnight and thence slowly. The air movement at Poona is hence remarkable for the great velocity between 4 P.M. and 9 P.M. and for the occurrence of the greatest velocity late in the afternoon at 7 P.M.

The wind at Belgaum is feeblest at 6 A.M. It thence increases until 10 A.M. and falls off slightly until 1 P.M., after which it increases rapidly to the maximum of the day at 5-30 P.M. It thence decreases very rapidly until midnight and thence slowly until 6 A.M. The variation of the movement is hence similar to that at Poona, except *that the maximum occurs about 1½ hours earlier and that the lag about mid-day* is much more marked at Belgaum than at Poona.

The diurnal variation in the north and east of the Peninsula as shown by the data for Nagpur and Pachmarhi is much less pronounced than at Belgaum and Poona. The air movement is feeble—practically constant in amount from 9 P.M. to 7 A.M. It thence increases up to the maximum of the day at about 2-30 P.M. and thence decreases until 9 P.M.

The variation in the Gangetic Plain and Rajputana is similar to that of the Central Provinces. The air movement is feeble and uniform during the night hours from 8 P.M. to 7 A.M. It thence increases from 7 A.M. to 3 P.M. or 4 P.M. when it is from two to three times as great on the average as during the night. It thence falls rapidly from 5 P.M. to 8 P.M. The curves for Hazaribagh, Lucknow, Jaipur, Agra and Lahore are all similar in character. The air movement is very light in the Punjab, barely averaging 4½ miles per hour at the hottest period of the day.

The variation at Rangoon is similar to that at Poona and Belgaum but of much smaller amplitude. The movement is least at 7 A.M. and greatest at 6 P.M.

The preceding remarks indicate generally the character of the diurnal variation of the air movement in different parts of India.

Over the whole of the interior (at a distance of upwards 100 or 150 miles from the coast) the air movement is very feeble and unsteady during the night hours from about 8 P.M. to 6 A.M. or 7 A.M. and is on the average practically constant throughout that period. The mean wind velocity at the great majority of the stations ranges between 2 and 5 miles and may be described as light airs and calms. It begins to increase at about 8 A.M., at first slowly and thence more and more rapidly up to the maximum at 2 P.M. to 3 P.M., when the air movement is from two to five times as vigorous as during the night. It thence decreases, generally more rapidly than it previously increased, from 4 P.M. to 8 P.M. when light airs and calms again set in. In the west coast districts, as shown by the data for Trivandrum, Bombay and Kurrachee, the diurnal variation is very strongly marked. The air movement is least at about 7 A.M. to 8 A.M. and greatest between 2 P.M. and 4 P.M.—the period of greatest convective movement in the interior. The wind velo*city at the maximum epoch at Kurrachee, Bhuj, Rajkot, Veraval and Bombay on the* northern half of the west coast frequently exceeds 25 to 30 miles per hour. An equally large increase of velocity occurs at stations within 100 or 150 miles from the west coast, including Deesa, Poona and Belgaum, but the maximum is from two to three hours later at these stations than at the neighbouring coast stations. The increase in the mean air movement, due to the increasing intensity of the normal conditions and actions during this period, is very clearly shown by the curves in Plate LII, representing the annual variation of the amount *of the air movement at the twenty-nine stations* at which hourly observations were recorded.

The diurnal variation of the air movement in Northern India is approximately given

by the wind data in the memoirs of the hourly observations. The following gives data for stations in that area :—

Station.	Mean hourly air movement in miles in March to May.		Epoch.	
	Minimum.	Maximum.	Minimum.	Maximum.
Lucknow	3·4	8·9	6 A.M.	3 P.M. and 4 P.M.
Agra	3·9	8·4	Midnight to 4 A.M.	2 P.M.
Deesa	7·1	13·5	7 A.M. and 8 A.M.	5 P.M.
Lahore	1·9	4·3	Midnight to 2 A.M.	4 P.M.
Jaipur	4·3	10·7	5 A.M.	3 P.M. and 4 P.M.

The preceding data indicate that the ratio of the night winds to the strongest day winds ranges between 2 and 3 over Northern India. Winds are feeblest during the night hours from 10 P.M. to 5 or 6 A.M., during which they vary little in strength, and are strongest from 2 P.M. to 4 P.M.and on the mean of all stations at 3 P.M. practically.

In Plates LIII and LIV are given curves showing the mean diurnal variation of velocity for the period for fifteen stations in India.

(2) *Diurnal variation of the direction of the lower air movement.*—On the west coast, as represented by Kurrachee, where winds range in mean direction between west and west-south-west, the air movement is from directions slightly more southerly than the mean between 11 A.M. and 8 P.M. and slightly more westerly than the mean from 2 P.M. to midnight. The maximum southing is at 2 P.M. and the maximum westing at 6 P.M. The diurnal variation at Deesa is similar in direction to that at Kurrachee and the maximum southing occurs at 3 P.M.

The diurnal variation is large and complicated at Belgaum and Poona. These stations in the West Deccan at the foot of the Ghats come under the influence of the strong westerly day winds blowing across the Bombay coast and the drift from north-east across the Deccan persistent throughout the day over the greater part of the area. The influence of the latter is strongest in the morning between 9 A.M. and 1 P.M. when winds are from north-easterly directions. It will be seen on reference to the curve (Fig. 10, Plate LIV) giving the diurnal variation of velocity that this period corresponds to a period of slightly diminished air movement. During the remainder of the day winds are from westerly directions with a slight northerly element from 2 A.M. to 8 A.M. and with a southerly element from 2 P.M. to 1 A.M.—strongest or most pronounced at 9 P.M. at Belgaum.

At Jaipur and Nagpur, probably representative of Rajputana, Central India and the Central Provinces, the mean wind directions are approximately north-west. Winds are more westerly than the mean during the day hours from about 11 A.M. to 7 P.M. and more northerly during the night hours. The air movement is hence more directly across the Deccan and Central India by day than by night. The westing is a maximum at these stations about 3 P.M. The diurnal variation at Pachmarhi (where the mean wind direction is west-north-west) is opposite to that at Nagpur and Jaipur.

The diurnal variation is small in amount in South Bengal. The mean winds are

from south-south-westerly or south-westerly directions at Calcutta, Saugor Island and Dacca in this period. Winds are more southerly than the mean during the day hours and more westerly during the night hours, but the mean shift is small, not exceeding two points.

An important effect of the increased strength of the sea winds blowing across the Bengal coast during this period is to give easterly winds during a part of the day up the Gangetic Valley as far west as Allahabad. The mean winds are from westerly directions in the North-Western Provinces and West Bihar, and hence at the stations in that area the diurnal variation gives a complete shift of the wind from easterly to westerly directions. At Patna winds are, on the mean of the period, from midnight to 11 A.M. (or for twelve hours) from easterly directions, whereas at Allahabad they are from easterly directions for four hours only, *viz.*, from 7 P.M. to 11 P.M.

In the Gangetic Plain, west of Allahabad, the diurnal variation varies largely in character at different stations. The Lucknow data (of doubtful value) indicate that winds are remarkably steady from north-westerly directions throughout the whole day.

At Roorkee and Lahore there is, on the other hand, a well marked diurnal variation apparently chiefly related to the up and down movement across the hills. At Roorkee winds are north westerly during the period of downflow from 3 P.M to 6 A.M and shift to east and south during the period of upflow. Similarly, at Lahore winds are from directions to the west of the mean direction from 11 A.M. to 7 P.M. and from directions to the east of the mean from 7 P.M. to 10 A.M.

The variation at Chittagong probably represents the conditions along the whole Arakan coast. Winds are, on the mean of the period, from south. There is a land influence from 11 P.M. to 11 A.M., giving winds ranging between south and south-east, and a strong sea influence (giving a westerly element) during the day hours from noon to 9 P.M. The easterly element is strongest at 8 A.M. and the westerly at 3 P.M.

At Bellary the variation is similar in general character to that at Chittagong but inverse in direction. The mean wind direction of the period is south. Winds are more easterly during the day hours from noon to 10 P.M., that is, during the period of increased indraught from the Bay. The easterly component is slight at noon. Winds have a westerly component from 10 P.M. to noon, most pronounced from 7 to 8 A.M. The variation ove the eastern half of the Peninsula, south of the latitude of Masulipatam, probably follows the same law at all stations.

The preceding data show that the diurnal variation of air movement at Jubbulpore, Nagpur, Trichinopoly and perhaps Bellary is similar in character to that in the Gangetic Plain. It is entirely different at Rangoon, Poona and Belgaum, where it is, however, similar to that at Calcutta and is due to the variations of the air movement or sea breezes in the coast districts. These winds are probably strongest on the coast about 2 or 3 P.M., but their maximum occurs later with increasing distance from the coast. These three stations (*viz.*, Rangoon, Poona and Belgaum) are all at about the same distance from the coast and less than Calcutta. The maximum velocity of the winds in their diurnal variation at these stations is about 6 P.M. and about two hours earlier than at Calcutta.

The air movement of the rainy season in India.—Fig. 4, Plate XLVIII, and Fig. 1, Plate XLIX, give isobars and the wind directions and steadiness in the months of June and August by means of wind arrows, the direction of which (flying

with the wind show) the mean direction of the wind and the length of the arrows proportionately to a length of five-eighths of an inch (which length indicates complete steadiness) the percentage of steadiness. The month of June shows the transition from the hot weather air movement to that of the rainy season and the month of August the lower air movement in the height of the rainy season.

A comparison of the charts for May and August will show that over the greater part of India, including Burma, North Eastern and Central India and the Peninsula, the direction of the air movement is almost identical. The character of the winds and accompanying weather in the two seasons are, however, utterly different, the changes being slight in the coast districts but large in the interior. The winds in May over the greater part of India are hot, dry and vigorous, and have a very strongly marked diurnal oscillation or variation. In August winds are, on the other hand, moderate and with a slight diurnal variation and the weather humid and rainy. The winds in May, as in August, are sea winds, but are purely local and only extend seawards to 100 to 300 miles from the coast districts, whereas in August they are part of a general air circulation extending over the whole of the Indian seas and the northern half and centre of the Indian Ocean. The processes by which the local circulation which obtains in India and the adjacent seas is transformed into the general circulation of the rainy season are explained in my paper on the "Origin of the Cold-Weather Storms in India" published in the Journal of the Royal Meteorological Society. The transformation commences in the south of the Bay in the latter part of May, and is usually completed over the whole of the Indian area before the end of June.

The following is a statement of the general character of the air movement over India in July and August when the south-west monsoon is fully established.

In the Arabian Sea winds range in direction from south-west in the south, centre and west of that area to west in the north and east, or in the neighbourhood of the Mekran and West India coasts. The average force of the winds is greater in that area than in the Bay of Bengal. Winds are, as a rule, strongest to the south and east of Socotra. The following gives comparative data:—

Month	Mean force of current in Arabian Sea.	Maximum force of current in Arabian Sea.	Area of strongest winds.	Minimum force of current in Arabian Sea.	Area of strongest winds
July	4·6	6·9	Between Lat. 16° N and Lat. 20° N and Long. 58° E and Long. 62° E.	1·5	Between Lat. 18° N and Lat. 12° N. and Long. 75° E and Long. 80° E.
August	4·3	7·2	Between Lat. 8° N and Lat. 12° N and Long. 54° E and Long. 58° E.	1·6	Between Lat. 24° N and Lat. 28° N and Long. 58° E and Long. 62° E.

The lower atmospheric current of the rainy season in the Arabian Sea crosses the

West Coast almost at right angles along its whole length (about 1,000 miles). The following data indicate the average strength of this current at different parts of the coast:—

Station.	Average normal velocity of wind per diem in July.	Average normal velocity of wind per diem in August.
	Miles.	Miles.
Kurrachee	415	397
Bhuj	399	356
Veraval	310	264
Bombay	450	376
Ratnagiri	312	244
Karwar	123	87
Mangalore	78	69
Cochin	131	133

It is probable that the average velocity of influx from the Arabian Sea in the lower atmospheric strata during the monsoon is from 350 to 400 miles per diem.

The air current over the south of the Bay passes partly into Burma across the South Pegu coast and partly into Bengal across the coast between Chittagong and False Point. The current advances almost parallel to the coast of the Circars and Ganjam and except during the prevalence of certain types of cyclonic storms, a very small portion of the Bay current crosses these coasts. The length of the Bengal Coast traversed directly by the current is barely 400 miles. The following data indicate the approximate velocity of the lower current at this stage:—

Station.	Average normal daily velocity of wind in July.	Average normal daily velocity of wind in August.
	Miles.	Miles.
False Point	277	238
Saugor Island	357	315
Jessore	111	99
Noakhali	163	161

The velocity hence averages about 215 miles per diem.

Hence assuming that, vertically, conditions are similar as regards height of the current and variation of velocity with height, the volume of the influx of the Bombay or Arabian Sea current exceeds that of the Bengal or North Bay current in the ratio of $1{,}500 \times 350 : 400 \times 215$ or $6 : 1$. The area dependent chiefly or solely upon the Bengal current (including Bengal, Assam, Bihar, Chota Nagpur, the North-Western Provinces and the East Punjab) is roughly 320,000 square miles, and the area mainly or solely dependent on the Bombay current 900,000 square miles, that is, about three times as great as that dependent on the Bay current. Assuming also that the humidity conditions of the two currents are similar, the preceding gives as a rough estimate of the importance of the two currents, the ratio of 2 to 1 (Bombay to Bay).

This estimate of the relative importance of the two branches of the monsoon currents agrees fairly well with the general facts of the total rainfall and distribution of rainfall in India during the south-west monsoon. Hence we have the following important conclusions:—

(1) The relative importance of the Bombay to the Bengal current, as measured by volume and velocity, or by rainfall, is approximately 2 : 1.

(2) There appears to be little difference between the elevation and rate of vertical change of velocity and of the humidity conditions of the two currents.

The direction of the air movement (*vide* chart, Fig. 1, Plate XLIX) over the greater part of the area dominated by the Bombay current (including the Peninsula, Gujarat, Kathiawar and Central India) is west with generally a feeble southerly element. In Rajputana and the West Punjab winds are generally from directions ranging between south and west.

The following table, giving mean daily air movement at stations where the anemometers are similarly exposed, shows the decreasing strength of the Bombay current as it advances landwards:—

Station.	Average normal daily wind velocity in July.	Average normal daily wind velocity in August.
	Miles.	Miles.
Poona	386	327
Sholapur	336	296
Hyderabad (Deccan)	249	203
Khandwa	217	199
Jubbulpore	114	101
Bhuj	399	356
Deesa	351	278
Ajmer	185	156
Jaipur	133	118

The previous remarks have hence shown that the direction of the movement of the Bombay current across the country is practically unchanged, ranging between west and south-west over nearly the whole area affected by it. The contrary is the case with the Bengal current. It crosses the coast nearly at right angles to its trend. In its further passage inland towards Upper India it is deflected by the Himalayas, and hence the main body of the current is deflected from south through south-east to east in its advance across Bengal and Bihar and the Gangetic Plain generally. The direction of the mean winds in the North-Western Provinces is between east and south-east or practically parallel to the Himalayas.

The following data indicate the decreased air movement in proceeding westwards up the Gangetic Plain during this period. The decrease in its landward progress is much less marked than in the case of the Bombay current:—

Station.	Average normal daily wind velocity in	
	July.	August.
	Miles.	Miles.
Calcutta	122	115
Burdwan	103	86
Patna	101	96
Allahabad	119	106
Lucknow	93	70
Delhi	107	99
Lahore	80	69

The chart for August (Fig. 1, Plate XLIX) indicates that over the whole of the country to the south of a line joining Saugor Island, Hazaribagh, Allahabad, Agra, Sirsa and Mooltan, a strong and steady horizontal air current from the west obtains.

A horizontal current of considerable steadiness advances across the Bengal coast giving winds the mean direction of which is south-south-east in South Bengal. This current advances up the Gangetic Plain to the East Punjab and is deflected by the mountain ranges to the north. The mean winds in the sub-montane districts of the Gangetic Plain are hence practically parallel to the axis of the plain and to the Himalayas. In the intermediate belt between the two areas of westerly and easterly winds, due to the two branches of the monsoon current in India, is a narrow elongated belt of country in which winds are remarkably unsteady and variable.

The following data indicate the position of this intermediate belt of variable winds:—

Stations to north.	Normal percentage of steadiness in August.	Stations in the intermediate belt.	Normal percentage of steadiness in August.	Stations to south.	Normal percentage of steadiness in August.
Patna	38	Hazaribagh	8	Sambalpur	42
Gorakhpur	38	Benares	11	Jubbulpore	64
Bareilly	16	Allahabad	4	Jaipur	43
Roorkee	22	Agra	7	Bikaner	49
Lahore	25	Delhi	6	Jacobabad	59
		Sirsa	16		

The following data give the air movement at these stations:—

Stations to North.	Normal wind velocity per diem in August.	Stations in the intermediate belt.	Normal wind velocity per diem in August.	Stations to South.	Normal wind velocity per diem in August.
	Miles.		Miles		Miles.
Patna	96	Hazaribagh . .	185	Sambalpur . .	72
Gorakhpur . .	55	Benares . . .	101	Jubbulpore . .	101
Bareilly	85	Allahabad . .	106	Jaipur	118
Roorkee	58	Agra	146	Bikaner . .	150
Lahore	69	Delhi	99	Jacobabad . .	101
		Sirsa	111		

The data hence show that in the intermediate belt the air movement although very unsteady and variable is stronger than at stations in the neighbourhood to the north and south. The position of the belt is very clearly indicated on the August chart, Fig. 1, Plate XLIX.

The chief abnormal features of the air movement in India during the period are:—

(1) The varying strength of the two currents.

(2) The varying position of the intermediate belt of low pressure and unsteady winds.

(3) The frequent occurrence of cyclonic storms.

The strengths of the two currents vary very considerably during the season. A strong influx of the humid currents accompanies very heavy rainfall in the interior, frequently at a greater rate than is supplied by the current. The rainfall under these conditions diminishes in the interior, the indraught falls off and the winds tend to become light and variable, more especially in the area dominated by the weaker or the Bay of Bengal current. Fine weather with passing clouds and local showers sets in for a few days in Northern and Central India and over the head of the Bay. Meanwhile, the winds continue in almost undiminished strength in the south of the Bay and the large supplies of aqueous vapour furnished by that movement tend to accumulate in the north of the Bay. Heavy rain recommences in the north of the Bay, more or less localized in its distribution, and in the majority of cases it gives rise to a cyclonic storm which advances landwards, carrying the humid currents and rainfall into the interior with it and giving another general burst of rainfall for some days. Then the rainfall diminishes and another period of light winds followed by the formation of another storm and an advance of a burst of rainfall occurs.

The Arabian Sea current is much steadier than the Bay current. The indraught across the West Coast, however, varies very considerably in strength, depending chiefly upon pressure conditions in the interior. These variations affect chiefly the extension of the area of rainfall which contracts seawards and expands landwards according to these conditions. The rainfall hence varies partly in intensity but chiefly in the extent of area over which it occurs.

The two currents do not necessarily vary simultaneously in strength, although they frequently do so. They are to some extent independent of each other, and hence their relative strengths vary. As the position of the intermediate belt will evidently depend upon the relative strength and area of extension of the two currents, it varies considerably, and apparently irregularly during the season.

The position of this belt is of considerable importance for several reasons, the chief being that cyclonic storms during this period almost invariably advance along this intermediate belt. It hence determines the distribution of the heavy cyclonic rainfall which accompanies the advance of the cyclonic storms of the period.

(*1*) *Diurnal variation of the velocity of the lower air movement.*—The diurnal variation of velocity at fifteen stations, for which data are given in the memoirs on the hourly observations, is shown by curves in Plates LV and LVI.

The diurnal variation of the air movement is small but well-marked at Bombay. There is a slight rise from midnight to 4 A.M. followed by a slight fall until 7 A.M. This variation is probably of very slight importance. The chief feature is a moderate increase of velocity from 9 A.M. to 3 P.M. followed by a more rapid decrease until 8 P.M. The curve shows clearly that there is on the Konkan Coast during this season a moderate increase of velocity during the period of increasing temperature in the interior.

The curves for Poona and Belgaum show a large day variation or oscillation due chiefly to the heating of the interior of the Peninsula. The air movement is least at about 6 A.M. and increases rapidly from 7 A.M. to 2 P.M. at Belgaum, when it is about twice as great as at 6 A.M. It decreases rapidly from 4 P.M. to 10 P.M., and thence more and more slowly during the night hours. The epochs of minimum and maximum velocity are one hour later at Poona than at Belgaum. The diurnal variation is hence large and pronounced in the West Deccan as represented by these two stations.

The diurnal variation is similar in character, although much less in actual amount in the Central Provinces as represented by Nagpur and Jubbulpore to that in the West Deccan. The air movement at these stations in its diurnal variation is feeblest at 3 A.M. It increases slightly until 7 A.M. and thence more rapidly up to a maximum at 3 P.M. when the wind velocity is about twice as great as at 3 A.M.

The character and amount of the variation of the velocity of the air movement are shown by the following data for the area covered by the Bombay monsoon current:—

Station.	Mean hourly velocity in miles.		Ratio.
	Maximum.	Minimum.	
Bombay	18·5	15·5	1·2
Deesa	14·3	9·1	1·6
Poona	22·2	9·1	2·4
Belgaum	29·7	16·2	1·8
Nagpur	9·2	4·4	2·1
Jubbulpore	6·2	2·8	2·2

The curves for Rangoon, Lucknow, Agra and Lahore show that the diurnal variation of the air movement in the area dominated by the Bay current is similar in character to that of the Bombay current. At all these stations the wind velocity is lowest in the early morning and increases up to a maximum between noon and 4 P.M. The curves are fairly symmetrical at these stations. The following table gives the maximum and minimum values of the wind velocity and the epochs of their occurrence at these stations :—

Station.	Mean hourly velocity in miles.		Ratio of maximum to minimum velocity.	Epoch of maximum.	Epoch of minimum.
	Maximum.	Minimum.			
Rangoon	7·3	2·4	3·0	4 P.M.	6 A.M.
Lucknow	6·7	3·1	2 2	Noon	9 and 10 P.M.
Agra	6·9	3·6	1·9	2 P.M.	Midnight
Lahore	3·3	1·8	2·1	1 ,,	3 and 4 A.M.

The ratios for the stations in the Gangetic Plain agree closely with those in the preceding table for stations under the influence of the Bombay current.

The data hence indicate very clearly that the indraught into India from the adjacent seas has a well marked diurnal variation during the south-west monsoon. It has a single maximum and minimum and is least in volume and intensity in the early morning hours from 3 A.M. to 6 A.M. The maximum is generally between 2 P.M. and 3 P M., and hence coincides very closely with the period of maximum temperature in its diurnal variation.

It is hence evident that there is during the period of increasing temperature in the day a large increase of convective movement and of uptake in the interior of India, and hence also a large increase in the indraught into India from the adjacent seas during the same period. This indraught decreases rapidly during the period of rapid decrease of temperature in the afternoon and evening hours from 3 P.M. or 4 P.M. to 8 P.M. and thence slightly during the night and until shortly before sunrise.

(2) *Diurnal variation in the direction of the air movement.*—Over the greater part of the area including the Peninsula excepting Berar and the Central Provinces and also in South-West Rajputana, where winds are on the mean from westerly directions with a slight southing, winds are more westerly and less southerly than the mean during the day hours. This westerly deflection is greatest at Belgaum about 10 A.M., at Bellary about noon, at Poona about 4 P.M., at Deesa about 11 A.M., and at Kurrachee about 5 A.M. During the evening and night hours the southerly element of the wind is strengthened and winds blow from directions slightly to the south of the mean direction. The deflection is small in amount, on the average in no case exceeding a point ($22\frac{1}{2}°$). The southerly element is strongest at Kurrachee at 1 P.M., at Deesa at 11 P.M., at Poona at 1 A.M., at Bellary at 8 P.M., and at Belgaum at 4 P.M.

In Berar, the Central Provinces, Central India and East and Central Rajputana, where the mean wind directions are westerly with a slight northing, winds are slightly more northerly than the mean during the day hours and slightly less northerly in the

night and morning hours. The northerly component is strongest at Jaipur at 10 A.M., at Jubbulpore at 4 P.M., at Pachmarhi at 1 P.M. and at Nagpur at 10 A.M.

The westerly element is most marked at Kurrachee at 8 A.M., at Jaipur at 10 A.M., at Jubbulpore at 10 A.M., at Pachmarhi at 6 A.M. and at Nagpur at 10 A.M.

The air movement over the greater part of the area under the influence of the Bombay current is remarkably steady.

The following gives data in illustration for seven stations :—

Station.	Normal percentage of steadiness.			
	June.	July.	August.	September.
Bombay	65	85	83	52
Bellary	78	88	87	75
Belgaum	78	87	89	75
Nagpur	52	69	64	37
Poona	78	90	89	77
Deesa	70	73	75	53
Kurrachee	85	85	88	87

The data indicate that over the greater part of the area the steadiness percentage ranges between 80 and 90 in July and August.

The easterly winds in the Gangetic Plain, the continuation of the Bay current, are remarkably unsteady compared with the westerly winds of Western India. The following gives data for five stations showing the unsteadiness of the winds in the Gangetic Plain throughout the rainy season from June to September :—

Station.	Normal percentage of wind steadiness in			
	June.	July.	August.	September.
Calcutta	59	63	56	42
Patna	48	39	38	37
Lucknow	16	15	14	18
Roorkee	17	33	22	7
Lahore	6	30	25	7

A comparison of the chart, Plate LI Figs. 1 and 2, giving the normal pressure and winds of the month of July at 8 A.M. and 4 P.M. shows the chief features of the diurnal variation of the direction of the air movement during the rainy season.

The air movement is almost unchanged in direction during the evening and night hours. The chart for 8 A.M. hence shows the mean winds during the night and early morning hours. The heating of the interior during the day hours produces little or no change in the wind direction over Burma, Bengal, the Peninsula and the North Bombay coast districts. Winds are during the day hours slightly more northerly in Rajputana and the eastern districts or stations of Central India. The only important variation or change is in the Gangetic Plain. The position of the trough of low pressure (as indicated by the winds) is shifted slightly southwards during the period of increasing temperature, and northwards during the remainder of the day. There are hence large local diurnal changes in the wind directions of stations situated in or near the mean position of the area of the trough of low pressure. The following gives examples of the large shift :—

	Mean wind direction July.	
	8 A.M.	4 P.M.
	°	°
Hazaribagh	S 45 W	S 63 E
Allahabad	S 27 W	N 10 E
Agra	S 24 W	S 68 E
Lucknow	S 28 E	N 23 E

The previous remarks indicate that the diurnal variation in the direction of the air movement in the rainy season is very slight in amount over the whole of India except part of the Gangetic Plain. There is a slight tendency to increased northing in Rajputana and Central India and increased westing in the Peninsula.

The air movement of the retreating south-west monsoon.—The air movement during this period is somewhat complex. The retreat or withdrawal of the south-west humid current is a much slower process than its establishment in June. It is most probable that its retreat is due partly to the decreasing strength of the indraught and partly to the development of high pressure conditions and air movements to the north and west of India antagonistic to the extension of the monsoon. The withdrawal of the monsoon is followed in North-West and Central India by the prevalence of remarkably fine, clear weather, low humidity and moderate and decreasing temperature. Its withdrawal from Upper India accompanies and is followed by a slow but fairly continuous increase of pressure during the next two months in the Persian area and Upper India. Light, unsteady winds from the north-west set in and increase slowly in steadiness and strength. The continued retreat of the current takes place somewhat differently in different years but usually by a series of steps. It first withdraws from Upper India, then in a fortnight or three weeks afterwards from the Gangetic Plain and Central India, and then after another similar interval from Bengal, usually in the third or fourth week of October. During the same period the monsoon current in the Arabian Sea has usually withdrawn to the south of Lat. 16° N. It continues to give occasional showers in the South Konkan and Malabar during October when it ceases as a rule to give further rain to India.

The Bay current continues to give occasional rain to Burma for a short time after it withdraws from Bengal. The length of this period of rainfall is very variable from year to year and is apparently chiefly dependent upon the changing pressure conditions in Upper Burma and South India.

The rains usually cease in Burma in the third or fourth week of October. Light unsteady or northerly winds gradually set in, accompanying a considerable rise of pressure in that area and a large change in the air movement. Hitherto the monsoon current in the Bay has extended over the whole area and the coasts of Burma and Bengal. Northerly winds now set in over the north of the Bay, and the monsoon current recurves in the Bay from south-west through south and south-east to east and north-east, and is determined to the East Coast and centre of the Peninsula. Heavy and fairly general rain occurs over the coast districts and occasional rain in the interior. The current continues to weaken and to retreat or contract southward, and in the latter half of November and the beginning of December it is restricted to the south of the Bay and gives rain to the Coromandel districts south of Nellore and to the interior districts of Southern India. It usually withdraws from the Bay about the middle of December by which time north-easterly winds, the continuation of the land winds now prevailing in Burma and Northern India, obtain over the whole area.

Usually by the middle of December north-east monsoon winds are established over the Indian Seas. A light drift from north-west obtains generally in Extra-Tropical India which is continued as a moderate movement over the Bay of Bengal from north-east and across the Madras Coast and the interior of the Peninsula as easterly winds and thence into the Arabian Sea where it forms part of the general north-easterly drift over that area.

The transitional period, including October and November when the land winds are as yet feeble and the Bay current is decaying and retreating, is remarkable for the lightness of the air movement in Northern and Central India.

The following gives data for a few stations :—

Station.	Normal daily wind velocity.	
	October.	November.
	Miles.	Miles.
Lahore	39	32
Roorkee	31	26
Lucknow	47	34
Allahabad	66	49
Jaipur	77	66
Patna	45	37
Calcutta	67	62
Hazaribagh	124	110
Sibsagar	48	40

The winds are remarkably unsteady in Upper India during the whole of the period. They are also very unsteady over the whole of the Gangetic Plain and Lower Bengal in the transition month of October, but the air movement increases rapidly

in steadiness as well as in strength during the two remaining months of the period. The following table gives data showing the monthly percentage of steadiness at seven representative stations in that area during the period :—

Station.	Percentage of steadiness in		
	October.	November.	December.
Calcutta	11	59	62
Patna	5	31	51
Hazaribagh	24	45	56
Allahabad	18	23	25
Lucknow	42	40	41
Roorkee	6	4	15
Lahore	11	18	20

The air movement is much stronger in the Peninsula than in Northern India. Fairly steady north-east to east winds obtain, strong in the Coromandel Coast districts and moderate in the Deccan and North Madras. The following gives data for twelve stations showing the intensity of the air movement in these areas during the period :—

	Velocity in miles per hour.			
	October.	November.	December.	Period.
Gopalpur	6·3	7·0	6·9	6·7
Masulipatam	4·4	5·5	5·7	5·2
Cocanada	7·4	10·8	10·0	9·4
Madras	5·0	6·8	7·6	6·5
Negapatam	3·7	5·2	6·8	5·2
Pamban	8·6	10·1	13·3	10·7
Hyderabad	4·0	3·7	3·4	3·7
Poona	5·8	5·8	5·7	5·8
Bellary	4·3	3·3	3·1	3·6
Trichinopoly	3·8	4·2	5·0	4·3
Bangalore	4·0	3·7	3·9	3·9
Tinnevelly	4·5	4·1	5·2	4·6

The following table gives percentage of steadiness for selected stations in the interior of the Peninsula :—

Station.	Percentage of steadiness in		
	October.	November.	December.
Nagpur	49	60	54
Poona	19	60	54
Belgaum	13	64	67
Bellary	14	55	69
Trichinopoly	28	54	67

Winds are fairly steady at the west coast stations during this period. They are most unsteady at Kurrachee and Trivandrum, as shown below:—

Station.	Percentage of steadiness in		
	October.	November.	December.
Kurrachee	61	18	23
Bombay	33	52	58
Trivandrum	41	18	17
Karwar	63	46	54

The preceding remarks have shown that there is no general circulation over the whole of India common to the whole period. The two chief features are the gradual decay and retreat of the south-west monsoon currents in possession at the commencement of the period and the initiation of the land winds in Upper India and their gradual extension over the whole Indian land and sea areas during the next three months. At the end of December the cold-weather air movement of the north-east monsoon is fully established.

Little is known of the upper air movement. The few cirrus clouds occasionally seen in this period indicate that in the highest strata there is a rapid drift from west or west-south-west. The height of the lower land current is probably even less than in the cold weather. There is probably a slight inflow above 3,000 or 4,000 feet from the north of the Bay and the Arabian Sea into the interior.

The diurnal variation of velocity is similar to that of the cold weather but is of smaller amplitude. The variation of direction is also similar to that of the cold weather over the greater part of the country.

Diurnal variation of the velocity of the lower air movement.—The mean diurnal variation of the velocity of the air movement is given by means of curves in Plates LV and LVI for fifteen stations in different parts of India.

The diurnal variation is generally less pronounced than in the hot weather and the rains. The variation for Bombay is probably typical of that which occurs along the whole west coast and shows very clearly the alternating influence of the land and sea breezes. The velocity is a minimum about midnight and increases up to a secondary maximum at about 8 A.M. (due to the land breeze) and falls to a secondary minimum at about noon. It thence increases rapidly to 4 P.M., the epoch of the absolute maximum (due to the sea breeze) and falls slightly until 8 P.M. and rapidly from that hour until 10 P.M. This is almost certainly the type of variation for all stations in India at which land and sea breezes prevail, and which are cut off by mountain ranges from the influence of the general air movement over the Indian area. It is, for example, also clearly shown by the Trivandrum curve.

The curves for Rangoon, Deesa, Poona and Belgaum are peculiar and unique. At the last station the velocity is nearly constant from 9 P.M. to 6 A.M. It increases very rapidly from 7 A.M. to 10 A.M. when winds are strongest and thence decreases steadily until 9 P.M. The air movement at Poona is very feeble from midnight to 8 A.M. when it averages 2½ miles per hour. It increases very rapidly up to the maximum of the day at noon when the velocity averages 9·3 miles per hour. It is almost unchanged in average amount until 7 P.M., after which it falls rapidly until midnight. The most noteworthy feature of the air movement at these stations is the early occurrence of the maximum velocity (about noon).

Over the east of the Peninsula, Berar, Hyderabad, the Central Provinces and the interior of Northern India and Central India the diurnal variation is of the normal type, having a single maximum and minimum at about 3 P.M. and 7 A.M. The air movement is very feeble during the night hours from 8 P.M. to 8 A.M. but is fairly steady in amount. It thence increases up to the maximum (between 1 P.M. and 3 P.M.) and decreases rapidly from 4 P.M. to 6 P.M. or 7 P.M.

During by far the greater part of the year, there is an interchange of air between the hills and plains in North-Western India. During the day hours the movement in the lower strata is from south, *i. e.*, from the plains to the hills, and during the night hours from the hills to the plains, and hence from northerly directions. It is hence an alternating movement with two minima corresponding to the periods of transition from one movement to the other. The movement changes from down to up in the morning and from up to down late in the afternoon. The morning minimum is as a rule at about 8 A.M. It is faintly marked in the cold weather and is very clearly exhibited in the hot weather, more especially in the month of May. The afternoon minimum is shown in all months except the rainy season from July to September. It occurs at 5 P.M. from October to January, 6 P.M. in February, 7 P.M. in March and 8 P.M. to 9 P.M. in April, May and June. The afternoon maximum (of the intensity of the southerly winds which occurs about 2 P.M.) is well marked from October to March or April. The night maximum of the intensity of the northerly or down winds varies very considerably, but occurs usually shortly before sunrise (about 5 A.M.).

The wind directions of stations at the foot of the hills in the cold and hot seasons when the mean winds in the open Gangatic Plain are from north-west are slightly modified in direction by the indraught to the inner ranges of the Himalayas during the day hours. The tendency due to this action is to decrease the northing of the winds during the day hours and hence to increase the westing. The day movement is strongest, but the night movement obtains for a considerably longer period of the day.

The previous discussion has given the chief features of the air movement over India. Charts and curves in illustration will be found in Plates XLVIII to LVI.

In Plate LII are given curves to show the annual variation in the velocity of the air movement at 29 stations in India. These curves are interesting as they show at a glance that the air movement in Northern India is strongest in the hot weather months, reaching its absolute maximum intensity in April or May and that it is on the other hand most vigorous in the area dominated by the Bombay south-west monsoon in July when the south-west monsoon is usually strongest and steadiest. The great majority of the curves have a single maximum and minimum, but the curves for Chittagong and Rangoon have a double maximum and minimum. The first maximum is in April, due to hot weather actions, and the second in July, when the south-west monsoon in the Bay is strongest. The curves for Madras and Trichinopoly also have two maxima and minima, the first maximum in May and the second in December.

Plates LIII to LVI give curves showing the diurnal variation of velocity at stations for each of the four seasons of the year, *viz.*:—

(1) January and February.
(2) March to May.
(3) June to September.
(4) October to December.

In Plates XLVIII and XLIX are given charts showing the mean winds and mean distribution of pressure in the months of January, March, May, June, August, October and December, and also for the year. These charts indicate the relations which subsist between the mean distribution of pressure and the mean direction of the air movement over India, but throw no light on the diurnal variation of the direction or intensity of the air movement.

Plates L and LI give the mean winds and pressure distribution obtaining at 8 A.M. and 4 P.M. of the months of January, April, July and November, and deserve careful examination.

The charts for January (Figs. 1 and 2, Plate L) represent the conditions in the midst of the cold weather in India. Gradients are steeper at 4 P.M. than at 8 A.M. and are associated in the interior with little change of direction of the winds but with increased strength and steadiness. The winds at most of the coast stations are from land directions at 8 A.M. On the Bombay and Madras and Bengal coasts they are at 4 P.M. almost without exception from the sea. There is hence in the coast districts during this period a more or less complete shift of wind from land to sea directions after 8 A.M. (usually between 10 A.M. and noon) followed by a return to land directions during the evening or night, at times which differ considerably from day to day and from station to station.

There is hence a large influx into the interior from the west during the day hours, whilst there is in the interior a strong flow from Upper and Central India to West Bengal and Bihar. As pressure decreases steadily and considerably during this period there must be a very large outflow in the middle or higher atmospheric strata of which no direct evidence is furnished by the ordinary meteorological observations.

Figs. 1 and 2 of Plate LI gives the distribution of pressure and mean winds at 8 A.M. and 4 P.M. of July in the height of the winds. Gradients are generally steeper at 4 P.M. than at 8 A.M., more especially in the western half of the Peninsula. There is little change of direction except in the debatable area in the southern half of the Gangetic Plain. Winds are stronger and much steadier in the day at 4 P.M. than at 8 A.M.

The charts for April (Figs. 3 and 4 of Plate L) are of peculiar interest.

The gradients at 8 A.M. are opposite in general direction to those which obtain at the same hour in January and are slightly smaller in amount. Notwithstanding this, the wind directions in North-Western and Central India are roughly speaking the same in direction. The most remarkable feature is the contrast between the distribution of pressure at 4 P.M. and 8 A.M. Pressure is nearly uniform in amount over the greater part of the interior at 4 P.M., whilst very steep gradients obtain in the coast districts of India (but not in Burma). The gradients are exceptionally steep in the west or Bombay coast districts. There is little change from 8 A.M. to 4 P.M. in the wind directions on that coast, but winds are much stronger and steadier at the latter hour on the Madras coast. Winds shift considerably and blow more directly from the sea than at 8 A.M.

November is the month of greatest serenity and least air movement over the whole of Northern and Central India and the North Deccan. Figs. 3 and 4, Plate LI, illustrate the distribution of pressure and mean winds at 8 A.M. and 4 P.M. of that month. Gradients are slightly steeper at 4 P.M. than at 8 A.M. but the general character of the distribution of pressure is practically the same at the two hours. Hence over the whole of the interior

winds are somewhat steadier at 4 P.M. than at 8 A.M., but the general direction of the air movement is unchanged. In the coast districts of Bombay and Madras winds shift from land to sea directions, and the two charts show very clearly the diurnal alternation of the land and sea breezes.

It is interesting to note that while the relation between the winds and gradients is on the whole satisfactorily shown in charts, Figs. 1 to 4, Plates XLVIII and XLIX, there are numerous examples of the winds being apparently opposed to the gradients. This is more especially seen on reference to the November charts.

The following table gives the normal wind directions at the hours of 8 A.M. and 4 P.M. in January at selected stations in Northern and Central India, the interior of the Peninsula and the coast districts :—

Area.	Station.	Normal wind direction in January.	
		8 A.M.	4 P.M.
Northern and Central India.	Jacobabad	N 22° E	N 25° W
	Lahore	N 88° W	N 47° W
	Roorkee	N 53° W	N 88° W
	Jaipur	N 6° E	N 61° W
	Deesa	N 56° E	N 60° W
	Jubbulpore	S 61° E	N 14° W
Interior of Peninsula	Poona	S 70° W	N 53° E
	Nagpur	N 13° E	S 66° E
	Bellary	S 38° E	S 78° E
	Trichinopoly	N 18° E	N 53° E
Coast Districts	Kurrachee	N 50° E	S 69° W
	Bombay	N 58° E	N 50° W
	Karwar	N 62° E	N 60° W
	Cochin	N 42° E	W
	Madras	N 16° E	N 61° E
	False Point	N 28° W	S 66° E
	Chittagong	N 28° E	N 85° W
	Akyab	N 21° E	N 78° W

The preceding data show that there is—

(1) a marked tendency to increasing westing of the winds during the day hours and decreasing westing or increased easting during the night hours in Northern India.

(2) a marked tendency to increasing easting in the interior of the Peninsula during the day hours.

The following gives similar data for the month of April :—

Area.	Station.	Normal wind direction in April.	
		8 A.M.	4 P.M.
Northern and Central India.	Lahore	N 31° E	N 48° W
	Roorkee	S 60° E	N 79° W
	Jaipur	N 34° W	N 65° W
	Deesa	N 88° W	S 75° W
	Saugor	S 53° W	N 71° W
	Jubbulpore	S 24° W	N 62° W
	Allahabad	N 86° W	N 48° W
	Patna	S 81° E	N 45° W
	Hazaribagh	S 55° W	N 57° W
	Burdwan	S 27° W	S 55° W
Interior of Peninsula	Nagpur	N 83° W	N 71° W
	Raipur	S 56° W	N 78° W
	Sholapur	N 45° W	N 21° E
	Bellary	N 69° W	N 69° E
	Bangalore	S 41° W	N 82° E
	Trichnopoly	S 34° W	S 76° E
Coast Districts	Madras	S 10° W	S 47° E
	False Point	S 38° W	S 15° W
	Calcutta (Alipore)	S 25° W	S 32° W
	Narayanganj	S 10° E	S 2° W

The preceding data indicate the very marked tendency to increased westing of the winds in Northern India and increased easting in the eastern half of the Peninsula during

the day hours. The general character of the diurnal variation is hence the same as in cold weather.

The following gives corresponding data for a few stations in July indicating the general character of the diurnal shift of wind in the rainy season :—

Area.	Station.	Normal wind direction in July.	
		8 A.M.	4 P.M.
Northern and Central India.	Lahore	S 42° E	N 85° E
	Agra	S 24° W	S 68° E
	Hazaribagh	S 45° W	S 63° E
	Sutna	S 74° W	N 76° W
	Deesa	S 61° W	S 32° W
	Jubbulpore	S 69° W	N 87° W
Interior of Peninsula	Raipur	S 49° W	S 73° W
	Akola	N 88° W	N 63° W
Coast Districts.	Chittagong	S 36° E	S 4° W
	Saugor Island	S 27° W	S 7° W
	False Point	S 59° W	S 34° W

The shift of wind from 8 A.M. to 4 P.M. is generally very small in amount in the rains.

The following gives corresponding data for the month of November. They indicate a strong tendency to increased westing of the winds in Northern India and increased easting over the greater part of the Peninsula in the day hours :—

Area.	Station.	Normal wind direction in November.	
		8 A.M.	4 P.M.
Northern and Central India.	Lahore	N 5° W	N 52° W
	Jacobabad	N 18° E	N 47° W
	Jaipur	N 1° W	N 24° W
	Roorkee	S 81° E	N 66° W
	Patna	S 60° W	N 45° W

Area.	Station.	Normal wind direction in November. 8 A.M.	4 P.M.
Interior of Peninsula	Pachmarhi	N 82° E.	N 33° E
	Nagpur	N 21° E	N 52° E
	Khandwa	N 74° E	N 39° E
	Akola	N 89° E	N 51° E
	Belgaum	S 87° E	N 59° E
	Trichinopoly	N 13° E	N 46° E
Coast Districts	Kurrachee	N 49° E	S 60° W
	Madras	N 1° E	N 35° E
	Vizagapatam	N 21° W	N 56° E
	False Point	N 19° W	N 50° E

CHAPTER VIII.

AIR PRESSURE.

In the present chapter are given firstly the more important features of the actual or unresolved diurnal oscillation and secondly the more important characteristics of the constants (*i.e.*, amplitudes and epochs) of the first four components of the Besselian resolution of the diurnal oscillation of pressure.

(*1*) *Chief features of the actual or unresolved diurnal oscillation of pressure.*—The following gives the most important characteristics of the actual (or unresolved) diurnal oscillation of pressure in India from the data of Tables CX to CXIII. In Plates LVII to LXII are given curves representing the diurnal variation of the air pressure of the four seasons of the year and of the whole year at thrity stations.

The first or early morning minimum occurs on the average of the year at 3-27 A.M. in Northern India and at 3-29 A.M. in the Peninsula. The mean variation in the epoch from these values is nearly 17 minutes in Northern India and 9 minutes in the Peninsula. The total or absolute range of variation is 82 minutes in Northern or Extra-Tropical India and 31 minutes in the Peninsula. The morning minimum is, on the whole, latest at the coast stations and in the Assam Valley and earliest at the most interior stations.

The morning maximum occurs on the mean day of the year in Northern India at 9-41 A.M. and in the Peninsula at 9-27 A. M., or considerably earlier in the latter than in the former case. The mean range of variation in the epoch is 7 minutes in Northern or Extra-Tropical India and in the Peninsula or Tropical India. The absolute variation is 30 minutes in Northern India and 24 minutes in the Peninsula. The epoch is slightly earlier at the coast stations than the interior stations, but the differences are small and not larger than the amounts of the mean probable errors.

The mean epoch of the afternoon minimum in Northern India is 4-32 P.M. and in the Peninsula 4-6 P.M., or 26 minutes earlier than in Northern India. The mean variation from these epochs is 24 minutes for Extra-Tropical India and 18 minutes for Tropical India, and the absolute range of variation 72 minutes in Extra-Tropical India and 47 minutes in Tropical India. The epoch is also slightly earlier under similar circumstances at the coast than the inland stations.

The mean epoch of the evening maximum in Extra-Tropical India is 10-31 P.M. and in Tropical India 10-19 P.M., or 12 minutes earlier than in the former case. The mean range of variation of the epoch is 12 minutes in the former and 10 minutes in the latter area and the absolute range of variation 38 minutes in both areas. This phase is slightly more irregular in its occurrence than that of the morning maximum The epoch of this phase is slightly earlier at the coast stations than at inland stations.

Hence we have the following general conclusions :—

(1) The epochs of the morning and evening maxima occur earlier in the day in Tropical than in Extra-Tropical India, by nearly equal amounts averaging 13 minutes for all stations.

(2) The epochs of the same phases are earlier at the coast stations than the inland stations by amounts differing slightly but averaging five minutes on the mean day of the year.

(3) The epochs of the morning minimum are practically simultaneous over India and are on the average only two minutes earlier on the mean day of the year in Extra-Tropical than in Tropical India. The epochs of the afternoon minimum are, on the other hand, considerably later in Extra-Tropical than in Tropical India by amounts averaging 26 minutes.

(4) The epochs of the morning minimum occur on the whole slightly earlier with increasing latitude, and those of the afternoon minimum slightly later with increasing latitude on the mean day of the year.

(5) The epochs of the morning and evening maxima and the afternoon minimum generally occur earlier at the coast stations than at the neighbouring plains stations in approximately the same latitude. The following table gives data of differences for alternate months at five coast and the neighbouring plains stations:—

Differences between the epochs of

Month.	Morning maximum.					Evening maximum.					Afternoon minimum.				
	Trivandrum *minus* Trichinopoly.	Madras *minus* Trichinopoly	Rangoon *minus* Calcutta.	Chittagong *minus* Calcutta.	Kurrachee *minus* Jaipur.	Trivandrum *minus* Trichinopoly.	Madras *minus* Trichinopoly.	Rangoon *minus* Calcutta.	Chittagong *minus* Calcutta.	Kurrachee *minus* Jaipur.	Trivandrum *minus* Trichinopoly.	Madras *minus* Trichinopoly.	Rangoon *minus* Calcutta.	Chittagong *minus* Calcutta.	Kurrachee *minus* Jaipur.
January .	−17	+ 3	−20	+ 1	−13	−12	−10	+18	+26	+10	−34	−14	−15	−12	−7
March .	−11	+ 3	−19	+ 1	−11	−31	−19	−12	−14	+10	−45	− 9	−17	+18	−26
May .	+ 7	− 7	−23	+11	−13	−18	+ 3	−15	+35	−10	−28	+ 3	−23	+ 4	+13
July .	+20	0	−19	− 7	− 9	−20	+10	−21	− 7	−10	−19	+14	− 1	− 9	−25
September	− 5	− 9	−14	−13	−16	−29	− 9	+ 7	+22	+ 8	−31	− 2	+ 3	−14	−17
November	−26	− 5	− 2	− 9	−16	−23	−17	+ 3	+ 7	+ 3	−36	−15	−14	− 3	− 9

In addition to the above we have the following more general conclusions:—

(1) The phases are on the mean of the year at the same local time very approximately at all stations. The diurnal pressure oscillation is hence propagated across India from east to west with the velocity of the sun's apparent daily movement.

(2) The previous conclusion is true not only for the mean day of the year but for the mean day of each month of the year.

The following paragraphs give a full discussion of the more important features of the epochs of the diurnal oscillation throughout the year.

(1) *Early morning minimum.*—The following table discloses some of the more important seasonal differences in the epochs of the early morning minimum :—

TABLE CX.

MONTH.	MEAN EPOCH OF EARLY MORNING MINIMUM IN Extra-Tropical India. (a)	MEAN EPOCH OF EARLY MORNING MINIMUM IN Tropical India. (b)	DIFFERENCE. (a)—(b)
January	4·14 A.M	3 42 A.M	+32 MIN.
February	3·50 "	3·37 "	+13 "
March	3·36 "	3·23 "	+13 "
April	3·12 "	3·13 "	— 1 "
May	2·52 "	3·11 "	—19 "
June	3· 4 "	3·33 "	—29 "
July	3·27 "	3·40 "	—13 "
August	3·28 "	3·38 "	—10 "
September	3·24 "	3·33 "	— 9 "
October	3·17 "	3·20 "	— 3 "
November	3·38 "	3·26 "	+12 "
December	3·57 "	3·38 "	+19 "
Year	3·27 "	3·29 "	— 2 "

The preceding data, more especially those of the final column, show how closely related the phenomena of this feature of the diurnal oscillation are to the period of the day. Thus in April and October when days and nights are of practically equal length over the whole of India, the difference between the epochs of the early minimum in Extra-Tropical and Tropical India is practically *nil.* The epochs are, on the average, 32 minutes later in January, and 29 minutes earlier in June in Extra-Tropical than in Tropical India.

The data show that for Northern or Extra-Trophical India the minimum epoch occurs latest in the day in the coldest month (January) and earliest in the hottest month (May). The range of variation in its time of occurrence during the year in that area is 1 hour 22 minutes. The epoch of the morning minimum is practically constant during the south-west monsoon months of fairly uniform temperature conditions (July to October).

During the cold weather the early morning minimum is delayed with increasing latitude in Extra-Tropical India. The retardation is most pronounced in December and January. The following gives data for four stations in illustration :—

STATION.	EPOCH OF THE FIRST OR MORNING MINIMUM. November. H.	M.	December. H.	M.	January. H.	M.	February. H.	M.	March. H.	M.
Nagpur	3	16	3	39	3	36	3	36	3	14
Jubbulpore	3	12	3	29	3	38	3	34	3	20
Jaipur	3	41	3	53	4	29	3	53	3	26
Lahore	3	55	4	49	5	5	4	19	4	15

The variation in the epoch of the morning minimum is slight in the Peninsula during the period from November to March and the minimum occurs practically at the same instant during the period over the whole of that area. The following gives data in illustration:—

Station.	Epoch of the first or morning minimum.									
	November.		December.		January.		February.		March.	
	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.
Trichinopoly	3	43	3	49	3	44	3	31	3	28
Madras	3	31	3	35	3	43	3	39	3	26
Bellary	3	28	3	30	3	30	3	25	3	24
Poona	2	48	3	26	3	24	3	37	3	15
Bombay	3	14	3	32	3	38	3	38	3	32
Belgaum	3	9	3	19	3	32	3	34	3	23

During the period from April to October the morning minimum occurs slightly earlier in Extra-Tropical India than in Tropical India, the acceleration increasing with increasing latitude, except over the southern half of the Peninsula, where it is, as in the preceding period, practically constant. The following data illustrate these features:—

Station.	Epoch of the first or morning minimum.					
	May.		July.		September.	
	H.	M.	H.	M.	H.	M.
Trichinopoly	3	39	3	41	3	30
Bellary	3	6	3	43	3	24
Poona	3	12	3	42	3	29
Nagpur	2	39	3	30	3	22
Jaipur	2	43	3	19	3	16
Lahore	2	41	2	46	3	4

The following table gives approximate normal epochs of the early morning minimum in different latitudes in the Indian land area for each month of the year :—

Month.	Lat. N.								
	12°	16°	20°	22°	24°	26°	28°	30°	32°
	A. M.	A. M.	A. M.	A. M.	A. M.	A. M.	A. M.	A. M.	A. M.
January	3 30	3 35	3 40	3 45	3 55	4 5	4 15	4 25	4 40
February	3 38	3 40	3 42	3 45	3 46	3 48	3 50	3 55	4 10
March	3 27	3 30	3 35	3 35	3 35	3 40	3 40	3 40	4 0
April	3 29	3 16	3 10	3 6	3 4	3 2	2 58	3 6	3 30
May	3 30	3 6	3 0	2 55	2 50	2 45	2 45	2 41	2 40
June	3 30	3 25	3 15	3 5	3 3	3 0	2 50	2 40	2 30
July	3 40	3 43	3 30	3 20	3 25	3 30	3 20	3 10	2 50
August	3 35	3 40	3 30	3 30	3 30	3 30	3 30	3 20	3 10
September	3 30	3 25	3 30	3 30	3 40	3 30	3 25	3 10	3 5
October	3 35	3 25	3 0	3 15	3 15	3 20	3 20	3 10	3 5
November	3 45	3 30	3 20	3 15	3 20	3 25	3 40	3 45	3 50
December	3 50	3 40	3 30	3 30	3 40	3 50	3 55	4 10	4 25

The early morning minimum is retarded at stations on the crests of mountain ridges when compared with plain stations in the same latitudes. The following gives data in illustration for the three hill stations of Agustia, Simla and-Pachmarhi and the neighbouring low level stations :—

Month.	Agustia *minus* Trivandrum.	Pachmarhi *minus* mean of Nagpur and Jubbulpore.	Simla *minus* mean of Lahore and Roorkee.
	Min.	Min.	Min.
January	8	32	30
February	14	13	6
March	13	15	33
April	7	20	50
May	— 1	14	46
June	—13	14	61
July	9	12	61
August	5	— 2	2
September	4	13	39
October	12	30	59
November	5	27	37
December	— 1	30	21
Mean of year	5	18	37

The retardation (indicated by the positive sign in the preceding table) is small in amount for Agustia and is large for Simla where it averages 37 minutes for the year. It is greater, as a rule, during the dry than the wet season. There are however irregularities in the differences which are, if real, difficult of explanation.

The early morning minimum is generally retarded at stations in mountain valleys. The following gives data for the stations of Sibsagar, Goalpara and Srinagar (the positive sign indicating retardation) :—

MONTH.	Sibsagar *minus* mean of Allahabad and Patna	Goalpara *minus* mean of Allahabad and Patna.	Srinagar *minus* Lahore.
	Min.	Min.	Min
January	3	26	−86
February	9	9	−24
March	19	17	−12
April	41	10	−6
May	46	−18	59
June	18	15	57
July	− 9	14	51
August	−29	19	16
September	8	18	22
October	27	28	40
November	15	52	14
December	16	47	59
MEAN OF YEAR	14	20	16

The epoch is generally earlier at the coast stations than the interior stations in the same latitude. The following gives variation data (difference of epochs at the coast stations and the normal latitude epochs in the same latitude given in the table in page 247) for several coast stations, *a plus* sign indicating acceleration and a *negative* sign retardation of the epoch :—

MONTH.	ACCELERATION OF MORNING MINIMUM EPOCH FROM NORMAL AT			
	Madras	Aden.	Chittagong.	Kurrachee.
	Min.	Min	Min.	Min
January	−12	+ 8	−31	+15
February	− 1	+ 19	−14	− 2
March	+ 2	+ 28	− 2	−14
April	+ 7	+ 14	−10	−23
May	+ 3	+ 40	−25	−20
June	+ 7	+ 96	−36	−28
July	+16	+101	−21	− 9
August	+13	+106	−16	− 4
September	+14	+ 46	−18	+ 4
October	+18	+ 44	− 5	+ 8
November	+10	+ 7	−35	− 6
December	+13	+ 19	−38	+ 9
MEAN OF YEAR	+ 7	+ 44	−21	− 6

The early morning minimum occurs earlier than the normal at Madras and Aden during practically the whole year, and at Kurrachee from September to January. It is, on the other hand, considerably delayed at Chittagong. The differences are large at Aden and Chittagong and opposite in character, thus showing the important influence due to local conditions.

There are some local variations from these general conclusions, more especially at the following stations: Calcutta, Cuttack, Belgaum, Poona and Deesa.

The following shows the variations from the normal latitude epochs at these stations, the minus sign prefixed to the amount denotes that the epoch is earlier, and plus sign that it occurs later than the normal epoch :—

Station.	Variation from the normal latitude epoch.					
	January.	March.	May.	July.	September.	November.
	Min.	Min.	Min.	Min.	Min.	Min.
Cuttack	− 4	− 1	+25	+12	+10	+15
Calcutta	+21	−10	+19	+38	+ 7	+27
Belgaum	− 3	− 7	−12	+ 4	− 5	−21
Deesa	−32	−34	−19	+ 5	−36	− 5
Poona	− 4	−17	+10	+ 7	+ 1	−36

The preceding data indicate that the morning minimum epoch is retarded during the greater part of the year at Cuttack and Calcutta. It is, on the other hand, generally accelerated at the stations of Deesa, Poona and Belgaum, the acceleration being most marked in the dry season.

The following is a summary of the results established above :—

(1) *The early morning minimum occurs at practically the same instant on the mean of the year over India.*

(2) *It occurs at the same instant in April and October over the whole of India, and is earlier in Extra-Tropical India than in Tropical India from April to October and later during the remainder of the year, the greatest retardation occurring in January and the greatest acceleration in June, the periods of shortest and longest days in Northern India.*

(3) *The epoch of the early morning minimum is delayed or retarded with increasing latitude in Extra-Tropical India from November to March and is accelerated with increasing latitude during the remainder of the year.*

(4) *The early morning minimum is earlier, as a rule, at the coast stations as compared with inland stations in the same latitudes.*

(5) *The morning minimum is delayed at stations on the crest of hills, the retardation apparently increasing with latitude and being very large in the Western Himalayas (perhaps owing to special air movements).*

(6) *The morning minimum is generally retarded at stations in valleys, more especially in high and deep mountain valleys.*

(7) *It is accelerated at Deesa, Poona and Belgaum, due to peculiarities of position with respect to local air movements, and is retarded at Cuttack and Calcutta, the variations being generally greatest in the dry season.*

(2) *The morning maximum.*—The following gives the mean monthly epochs of the morning maximum in Tropical and Extra-Tropical India :—

TABLE CXI.

Month.	Mean Epoch of morning maximum in		
	Extra-Tropical India. (a)	Tropical India. (b)	Difference (a)—(b).
January	9·48 A.M.	9·34 A.M.	14 MIN.
February	9·57 "	9·41 "	16 "
March	9·47 "	9·31 "	16 "
April	9·39 "	9·25 "	14 "
May	9·34 "	9·17 "	17 "
June	9·27 "	9·18 "	9 "
July	9·38 "	9·33 "	5 "
August	9·41 "	9·36 "	5 "
September	9·38 "	9·27 "	11 "
October	9·30 "	9·18 "	12 "
November	9·33 "	9·19 "	14 "
December	9·42 "	9·26 "	16 "
Year	9·41 "	9·27 "	14 "

The mean epoch of the morning maximum in Tropical India is 9·27 A.M. and the mean range of variation during the year, as given by the monthly mean epochs, 24 minutes.

The mean epoch of the morning maximum in Extra-Tropical India is 9·41 A.M. and the monthly range of variation 30 minutes, or only one-third of the variation of the epoch of the early morning minimum during the year in that area. The morning maximum is later in Extra-Tropical than in Tropical India throughout the whole year. The differences are almost constant in amount throughout the period from November to May, averaging 15 minutes, and are slightly less during the remainder of the year, decreasing to 5 minutes in the height of the rains.

The data of the preceding table also show clearly that the morning maximum occurs slightly later over the whole of India in the cold weather than in the hot weather and the rains. It is earliest in June in Extra-Tropical India and in May in Tropical India. It is also slightly earlier over the whole area in October than in the preceding months of July, August, September and also the succeeding months of November and December.

The data also establish that the maximum epoch is earlier in Tropical than in Extra-Tropical India. In the former area it occurs after the mean epoch of the year from January to March and in July and August, and in Extra-Tropical India from December to March. The retardation is greater in Extra-Tropical than in Tropical India, and the differences between the mean epochs range between five minutes in July and August and 17 minutes in May.

It may also be noted that this epoch is practically constant during the greater part of the year at stations in the Peninsula. The following gives data for five stations :—

Station.	Epoch of morning maximum of pressure in							
	January.		May.		July.		October.	
	H.	M.	H.	M.	H.	M.	H.	M.
Trivandrum	9	17	9	22	9	30	9	3
Trichinopoly	9	34	9	15	9	10	9	18
Madras	9	37	9	8	9	10	9	10
Bellary	9	38	9	26	9	30	9	20
Belgaum	9	27	9	14	9	27	9	20

The data for stations in Northern India indicate clearly that high temperature and large diurnal range of temperature are associated with early epochs. This is shown by the following data for seven stations in Extra-Tropical India :—

Station.	Epoch of morning maximum of pressure in											
	January.		May.		June.		July.		August.		October.	
	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.
Deesa	9	42	9	1	8	57	9	28	9	28	9	16
Patna	9	37	9	22	9	20	9	49	9	44	9	26
Allahabad	9	47	9	37	9	12	9	44	9	58	9	29
Jaipur	9	50	9	40	9	26	9	37	9	40	9	30
Lucknow	9	58	9	37	9	38	9	36	9	51	9	34
Roorkee	10	2	9	45	9	26	9	56	10	8	9	42
Lahore	10	8	10	2	9	41	9	35	9	42	9	46

The data also show that the morning maximum, as the morning minimum, is delayed with increasing latitude in Extra-Tropical India from November to March (the retardation being greatest in February). It is, on the other hand, retarded in the rainy season in the areas of heavy rainfall and is earliest during that season in the hot and comparatively dry area of North-Western India, and is actually earliest at Deesa in June and at Lahore in July.

The following table gives approximate normal epochs of the morning maximum in different latitudes in the Indian land area for each month of the year :—

Month.	Lat. N.								
	12°	16°	20°	22°	24°	26°	28°	30°	32°
	A.M.	A.M.	A.M.	A.M.	A.M.	A.M.	A.M.	A.M.	A.M.
January	9 35	9 40	9 40	9 40	9 40	9 45	9 55	10 0	10 10
February	9 35	9 40	9 45	9 45	9 50	9 55	10 0	10 15	10 35
March	9 30	9 35	9 35	9 40	9 42	9 45	9 52	10 5	10 10
April	9 25	9 30	9 30	9 35	9 35	9 35	9 40	9 50	10 0
May	9 15	9 15	9 15	9 15	9 25	9 35	9 35	9 45	10 0
June	9 10	9 20	9 20	9 25	9 25	9 25	9 30	9 35	9 40
July	9 10	9 30	9 40	9 45	9 50	9 50	9 45	9 40	9 40
August	9 18	9 24	9 40	9 45	9 50	9 50	9 45	9 45	9 45
September	9 20	9 25	9 27	9 30	9 30	9 30	9 35	9 45	9 55
October	9 15	9 20	9 21	9 25	9 30	9 30	9 35	9 40	9 45
November	9 20	9 25	9 25	9 25	9 28	9 30	9 40	9 55	9 50
December	9 30	9 35	9 40	9 40	9 40	9 40	9 50	10 0	10 5

The following give the more important local peculiarities in the occurrence of the early morning maximum.

(1) The epoch of the morning maximum is accelerated locally at the stations of Deesa, Poona and Belgaum.

The following gives data in illustration :—

Month.	Acceleration of epoch from normal at		
	Belgaum.	Poona.	Deesa.
January	13	21	—2
February	6	17	3
March	5	17	4
April	10	26	12
May	1	16	24
June	4	12	28
July	3	—12	22
August	—18	8	22
September	— 8	4	2
October	0	16	14
November	13	22	12
December	17	24	7
Mean	4	14	12

The acceleration is greatest in the dry season, the period of land and sea breezes on the West Coast, and is least in the wet season, when it is practically *nil.*

(2) The epoch of the morning maximum is generally accelerated at valley stations, as is shown by the following data :—

Month.	Acceleration of epoch from normal at			
	Sibsagar.	Goalpara.	Leh.	Srinagar.
January	13	2	31	—24
February	15	17	52	1
March	14	28	42	12
April	5	10	55	0
May	3	8	86	56
June	5	—11	66	46
July	10	19	63	23
August	11	10	61	34
September	1	— 6	53	26
October	8	— 3	34	28
November	6	— 6	28	4
December	18	10	28	— 8
Mean of year	9	6	50	17

The acceleration is moderate at the Assam Valley stations, averaging 8 minutes on the mean of the year and is large at Srinagar and Leh, averaging 50 minutes at the latter station.

(3) The epoch of the morning maximum is slightly accelerated at the coast stations as compared with the interior stations. The following gives comparative data for six pairs of stations (the positive sign indicating acceleration :—

Month.	Mean of Patna and Allahabad *minus* Chittagong.	Mean of Trichinopoly and Belgaum *minus* Aden.	Trichinopoly *minus* Madras.	Allahabad *minus* Kurrachee.	Calcutta *minus* Chittagong.	Trichinopoly *minus* Trivandrum.
	Min.	Min.	Min.	Min.	Min.	Min.
January	— 7	+ 1	— 3	+10	— 1	+17
February	— 4	+ 3	— 3	+ 9	— 3	+14
March	— 9	—18	— 3	— 1	— 1	+11
April	—22	—25	+ 7	+ 1	—13	+ 3
May	—24	—20	+ 7	+10	—11	— 7

MONTH.	Mean of Patna and Allahabad *minus* Chittagong.	Mean of Trichinopoly and Belgaum *minus* Aden.	Trichinopoly *minus* Madras.	Allahabad *minus* Kurrachee.	Calcutta *minus* Chittagong.	Trichinopoly *minus* Trivandrum.
	Min.	Min.	Min.	Min.	Min.	Min.
June	−15	− 1	+ 2	− 9	+ 7	−19
July	+ 5	−11	0	+16	+ 7	−20
August	− 4	+ 9	+ 3	+55?	− 4	− 5
September	− 3	+ 4	+ 9	+ 8	+13	+ 5
October	0	+ 6	+ 8	+17	+ 3	+15
November	+ 9	+14	+ 5	+ 9	+ 9	+20
December	+ 6	+ 6	+ 9	+11	+ 6	+24
MEAN OF YEAR	− 6	− 3	+ 3	+11	+ 1	+ 5

The acceleration holds on the mean of the year at four out of the six stations and is moderate in amount at Kurrachee and Trivandrum. The epoch is, on the other hand, delayed in eight months at Chittagong.

(4) The epoch of the morning maximum is more or less considerably delayed at stations on mountain crests or ridges. The following gives data of the retardation for Agustia, Simla and Pachmarhi :—

MONTH.	Agustia *minus* Trivandrum.	Simla *minus* mean of Lahore and Roorkee.	Pachmarhi *minus* mean of Nagpur and Jubbulpore.
	Min.	Min.	Min
January	33	13	21
February	49	15	23
March	50	36	25
April	30	40	35
May	19	55	50
June	20	71	35
July	32	49	27
August	33	42	29
September	29	35	31
October	31	25	25
November	31	8	28
December	29	12	19
MEAN OF YEAR	32	34	29

The retardation is very approximately half an hour at these stations. It is fairly uniform in amount throughout the year at Agustia and Pachmarhi but varies largely at Simla, being least in the cold weather and greatest in the hot weather months of May and June.

The following is a summary of the results obtained in the preceding discussion:—

(1) *The epoch of the morning maximum is later in all months in Extra-Tropical than in Tropical India by amounts averaging 14 minutes for the whole year.*

(2) *The retardation is small in amount during the rains, averaging 7 minutes from June to September and is nearly constant in amount from November to May averaging 15 minutes.*

(3) *The absolute range of variation of the epoch of the morning maximum is much smaller than that of the morning minimum.*

(4) *The epoch is slightly later than the mean in both Extra-Tropical and Tropical India in the cold weather season from December to March, the retardation being slightly more marked in the former than the latter area. The epochs are earliest in May or June and again in October and November. There is a slight retardation in both areas during the rainy season in July and August, as marked in Tropical as in Extra-Tropical India.*

(5) *The epoch of the morning maximum varies very slightly with latitude in Tropical India. It is delayed with increasing latitude in Extra-Tropical India from November to March (the retardation being greatest in February) and is slightly accelerated with increasing latitude from April to October.*

(6) *The epoch of the morning maximum is slightly earlier in the coast than in the interior districts.*

(7) *It is slightly earlier in valleys, more especially high and deep mountain valleys.*

(8) *It is considerably retarded on the crests of mountain ridges.*

(9) *It is locally accelerated at the following stations—Poona, Belgaum, Deesa and Cuttack.*

(3) *Afternoon minimum.*—The following table gives the mean hour of its occurrence in each month of the year in Extra-Tropical and Tropical India:—

TABLE CXII.

Month.	Mean epoch of afternoon minimum in		
	Extra-Tropical India. (*a*).	Tropical India. (*b*)	Difference (*a*)—(*b*).
January	3·54 P.M.	3·50 P.M.	4 MIN.
February	4·17 "	4·10 "	7 "
March	4·31 "	4·21 "	10 "
April	4·47 "	4·26 "	21 "
May	5·1 "	4·25 "	36 "
June	5·1 "	4·24 "	37 "
July	4·54 "	4·26 "	28 "
August	4·47 "	4·22 "	25 "
September	4·23 "	3·57 "	26 "
October	4·7 "	3·43 "	24 "
November	3·49 "	3·42 "	7 "
December	3·50 "	3·39 "	11 "
Year	4·32 "	4·6 "	26 "

The preceding data establish that the afternoon minimum is later in the day throughout the year in Extra-Tropical India than in Tropical India. It occurs on the mean

day of the year at 4-32 P.M. in Extra-Tropical India and at 4·6 P.M. in Tropical India, a difference of 26 minutes. The difference is least in the month of January or in the height of the cold weather, when it is only four minutes. It increases steadily until June when it averages 37 minutes.

The afternoon minimum occurs earliest in the day in December over nearly the whole of India and latest in May or June in Extra-Tropical India, and from April to July (during which period it is practically constant) in Tropical India. The annual range of the epoch in the former area is 1 hour 12 minutes and in the latter 47 minutes.

It generally occurs slightly later with increasing latitude in Extra-Tropical India from October to March or April. The following gives data for six stations :—

Station.	Epoch of afternoon minimum of pressure in									
	November.		December.		January.		February.		March.	
	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.
Nagpur	15	37	15	50	16	0	16	19	16	31
Jubbulpore	15	50	15	54	16	11	16	17	16	26
Jaipur	15	36	15	45	15	39	16	17	16	31
Allahabad	15	40	15	44	15	53	16	20	16	39
Roorkee	15	52	16	3	15	54	16	9	16	40
Lahore	15	56	16	23	16	12	16	36	16	48

The variation of the epoch from month to month at stations in Tropical India is generally small in amount, but irregular in character.

In Extra-Tropical India the variation with latitude is somewhat irregular and is largish in amount from May to October, as is shown by the following data :—

Station.	Epoch of afternoon minimum of pressure in											
	May.		June.		July.		August.		September.		October.	
	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.
Nagpur	16	33	16	41	16	45	16	25	15	57	15	44
Jubbulpore	16	28	16	13	16	27	16	22	16	9	16	0
Allahabad	17	9	16	53	16	45	16	45	16	25	16	7
Jaipur	16	36	17	16	16	57	16	42	16	25	16	3
Lahore	17	19	17	32	17	34	17	24	16	44	16	33

There is a fairly well-marked tendency to retardation or delay of the epoch during this period with increasing latitude.

The following table gives approximate normal epochs of the afternoon minimum in different latitudes in the Indian land area for each month of the year:—

Month.	Latitude N.								
	12°	16°	20°	22°	24°	26°	28°	30°	32°
	P. M.	P. M.	P. M.	P.M.	P. M.	P. M.	P. M.	P. M.	P. M.
January	3 55	4 0	4 5	4 10	4 5	4 0	4 0	3 55	4 10
February	4 10	4 15	4 20	4 20	4 22	4 24	4 26	4 30	4 35
March	4 15	4 25	4 30	4 30	4 34	4 37	4 40	4 43	4 45
April	4 20	4 30	4 35	4 40	4 45	4 50	4 55	5 0	5 5
May	4 20	4 30	4 35	4 40	5 0	5 5	5 10	5 15	5 20
June	4 25	4 35	4 40	4 45	4 50	5 0	5 10	5 20	5 30
July	4 10	4 15	4 25	4 35	4 40	4 45	4 55	5 15	5 30
August	4 5	4 25	4 25	4 30	4 35	4 40	4 50	5 5	5 20
September	4 0	4 5	4 5	4 10	4 15	4 25	4 35	4 40	4 45
October	3 45	3 45	3 45	4 0	4 5	4 5	4 10	4 15	4 30
November	3 45	3 45	3 50	3 55	3 50	3 50	4 0	4 0	4 0
December	3 45	3 45	3 50	3 55	3 50	3 50	3 55	4 5	4 20

There are certain local peculiarities in the occurrence of the epoch of the afternoon minimum which deserve notice. The first case is that of the stations of Belgaum, Poona and Deesa, at which stations it is accelerated by the amounts shown in the following table:—

Month.	Amount of acceleration of epoch of afternoon minimum of pressure from normal of latitude at		
	Belgaum.	Poona.	Deesa.
	Min.	Min.	Min.
January	26	33	26
February	22	13	16
March	28	24	30
April	27	37	41
May	27	34	15
June	30	32	1
July	10	—6	—11
August	15	—3	—3
September	37	35	7
October	22	18	21
November	31	10	13
December	5	17	8
Mean	23	20	14

Whence in virtue of local peculiarities the afternoon minimum is accelerated about 23 minutes at Belgaum, 20 minutes at Poona and 14 minutes at Deesa. The acceleration is at Belgaum and Poona greatest in the cold and hot weather seasons and least in the height of the rainy season (July and August).

The second case is that of Leh, Srinagar, Sibsagar and Goalpara, where the afternoon minimum appears to be accelerated by their position in valleys:—

Month.	Approximate amount of acceleration of epoch of afternoon minimum of pressure at			
	Leh.	Goalpara.	Sibsagar.	Srinagar.
	Min.	Min.	Min.	Min.
January	33	11	4	27
February	37	18	16	33
March	20	4	19	23
April	26	6	17	46
May	58	—13	23	33
June	39	8	33	62
July	30	— 3	10	—12
August	35	— 4	2	21
September	14	— 6	7	14
October	0	—14	— 6	13
November	3	— 9	— 9	54
December	33	— 6	— 5	20
Mean of year	27	— 1	9	28

The acceleration is very strongly marked at Leh in the deep Upper Indus Valley and at Srinagar in the Kashmir Valley. It is shown at Sibsagar and Goalpara during the period January to April, and is slightly greater in amount at the former than the latter station.

The third case is that of certain coast stations where a comparison with the neighbouring inland stations shows that there is a slight to moderate acceleration of the afternoon minimum due to their position.

The following table gives a comparison for the four coast stations of Trivandrum, Madras, Kurrachee and Chittagong with the nearest inland stations, a minus sign prefixed to the figures denoting that the afternoon minimum occurs earlier at the coast stations than the inland stations, and a positive sign that it occurs later:—

Month.	Difference between the epochs of afternoon minimum of pressure.							
	Trivandrum *minus* Trichinopoly.	Madras *minus* Trichinopoly.	Kurrachee *minus* Deesa.	Kurrachee *minus* Jaipur.	Kurrachee *minus* Agra.	Kurrachee *minus* Lahore.	Chittagong *minus* Calcutta.	Chittagong *minus* Patna.
	Min.	Min.	Min.	Min.	Min.	Min.	Min.	Min.
January	—34	—14	— 6	— 7	—28	—40	—12	—25
February	—41	—17	+ 2	— 9	—14	—28	— 9	— 1
March	—45	— 9	+ 1	—26	—34	—43	+18	+14
April	—45	— 3	+23	—20	—35	—33	+13	+ 9
May	—28	+ 3	+ 3	+13	—23	—30	+ 4	— 4

Month.	Difference between the epochs of afternoon minimum of pressure.							
	Trivandrum *minus* Trichinopoly.	Madras *minus* Trichinopoly.	Kurrachee *minus* Deesa.	Kurrachee *minus* Jaipur.	Kurrachee *minus* Agra.	Kurrachee *minus* Lahore.	Chittagong *minus* Calcutta.	Chittagong *minus* Patna.
	Min.	Min	Min.	Min.	Min	Min.	Min.	Min.
June	−20	+15	−4	−30	−38	−46	+19	+ 9
July	−19	+14	−20	−25	−37	−62	− 9	− 6
August	−22	+15	−10	−13	−36	−55	− 8	− 4
September	−31	− 2	− 1	−17	−47	−36	−14	−19
October	−31	− 6	− 7	−26	−34	−56	− 1	− 9
November	− 6	−15	−10	− 9	−38	−29	− 3	−21
December	−32	−21	−15	− 8	−24	−56	−11	−19
Mean of year	−32	− 3	− 4	−16	−32	−43	− 1	− 6

Whence during the greater part of the year the epoch is earlier at the coast than the inland stations in the same latitude and under similar conditions. The exceptions appear to occur in the hot weather and rains, when the differences are very small, due probably to the very slight contrast between sea and inland temperature conditions in India.

The last case is that of the hill station of Agustia, situated on the crest of the Travancore hills, where the afternoon minimum occurs considerably later than at the neighbouring low-level stations. The same feature is exhibited at Pachmarhi and Simla during a part of the year.

The following gives comparative data in illustration (the positive sign indicating delay):—

Month.	Difference between the epochs of afternoon minimum of pressure.		
	Agustia *minus* Trivandrum.	Simla *minus* mean of Lahore and Roorkee.	Pachmarhi *minus* mean of Jubbulpore and Nagpur.
	Min.	Min.	Min.
January	+18	− 9	−29
February	+35	+37	−16
March	+44	−15	−10
April	+26	− 7	+ 3
May	+ 9	+ 9	+14
June	+12	0	+12
July	+31	−13	+ 8
August	+32	−12	+ 7
September	+47	+ 7	+ 7
October	+30	−26	− 3
November	+15	+ 8	− 2
December	+ 8	−13	−23
Mean of year	+26	−3	− 3

The *minus* sign in the preceding table indicates that the epoch occurs earlier at the hill stations in question than at the neighbouring plain stations. The retardation is very marked at Agustia. At Simla and Pachmarhi the epoch is generally accelerated during the dry season and delayed in the damp season.

The following is a summary of the results of the preceding discussion :—

(*1*) *The afternoon minimum occurs later in all months in Extra-Tropical than in Tropical India. The retardation averages on the mean of the year 26 minutes. It is least in January when it is only 4 minutes and is greatest in June when it is 37 minutes.*

(2) *The afternoon minimum occurs earliest in the day over the whole of India in December and latest in May and June. In Tropical India the epoch ranges from 3-39* P.M. *in December to 4-25* P.M. *in the period April to July when it is constant. In Extra-Tropical India it ranges from 3-50* P.M. *in November and December to 5-1* P.M. *in May and June. The epoch is hence considerably retarded during the period of increasing temperature from January to April or May, is fairly constant during the period June to September and is considerably accelerated during the period of decreasing temperature from September to December.*

(*3*) *It is slightly retarded with increasing latitude in Extra-Tropical India from October to March or April and is considerably retarded during the remainder of the year.*

(*4*) *The afternoon minimum is considerably accelerated at Poona, Deesa and Belgaum. This acceleration is greatest in actual amount in the period from January to May and is slight during the rains.*

(*5*) *It is also accelerated at stations in valleys and more especially in high and deep mountain valleys* (*e.g., Leh and Srinagar*).

(*6*) *It is also slightly accelerated at the coast stations as compared with the interior stations in similar latitudes.*

(*7*) *It is, on the other hand, retarded at high stations situated on the crest or ridges of mountains. The retardation is very marked at Agustia, but is very slightly and doubtfully exhibited at Simla and Pachmarhi*

(*8*) *Hence the epoch of the afternoon minimum is as variable as that of the morning minimum, and the periods of its earliest and latest occurrence are also practically simultaneous. The epoch of the afternoon minimum is latest when that of the morning minimum is earliest, and vice versâ.*

(*4*) *Evening maximum.*—The following gives the mean epochs of the evening maximum for each month of the year in Extra-Tropical and Tropical India :—

TABLE CXIII.

Month.	Mean epoch of evening maximum in Extra-Tropical India. (*a*)	Mean epoch of evening maximum in Tropical India. (*b*)	Difference, (*a*)—(*b*)
January	10-11 P.M.	10-14 P.M.	— 3 MIN.
February	10-32 "	10-28 "	4 "
March	10-37 "	10-29 "	8 "
April	10-35 "	10-26 "	9 "
May	10-38 "	10-39 "	— 1 "
June	10-47 "	10-26 "	21 "
July	10-47 "	10-26 "	21 "
August	10-38 "	10-21 "	17 "
September	10-34 "	10-15 "	19 "
October	10-13 "	10- 3 "	10 "
November	10- 9 "	10- 1 "	8 "
December	10-12 "	10- 7 "	5 "
Year	10-31 "	10-19 "	12 "

The epoch of this phase in Extra-Tropical India is earliest from October to January (when it is practically constant) and latest in June and July. The range of variation during the year is 38 minutes, and is hence slightly greater than that of the morning maximum.

The monthly differences between the mean epochs in Extra-Tropical and Tropical India are small from October to May, averaging only five minutes. They are nearly constant in amount from June to September, averaging twenty minutes.

The evening maximum in Tropical India, as the afternoon minimum, occurs earliest in the day during the cold weather (from October to January) and latest in the month of May.

The following table gives approximate normal epochs of the evening maximm for each month of the year in different latitudes in India :—

Month.	Lat. N.									
	8°	12°	16°	20°	22°	24°	26°	28°	30°	32°
	P. M.	P. M.	P. M.	P. M.	P. M.	P. M.	P. M.	P. M.	P. M.	P. M
January . . .	10 5	10 10	10 15	10 10	10 5	10 10	10 10	10 10	10 10	10 20
February . . .	10 10	10 30	10 35	10 30	10 25	10 30	10 35	10 35	10 40	10 45
March . . .	10 5	10 30	10 40	10 30	10 25	10 35	10 45	10 35	10 30	10 50
April . . .	10 5	10 20	10 30	10 35	10 40	10 45	10 40	10 30	10 35	10 40
May	10 0	10 15	10 30	10 35	10 45	10 47	10 50	10 50	10 45	10 45
June	10 0	10 20	10 25	10 30	10 35	10 40	10 50	11 0	11 10	11 15
July	10 5	10 20	10 30	10 35	10 40	10 40	10 45	10 50	11 5	11 20
August . . .	10 0	10 25	10 30	10 35	10 35	10 40	10 40	10 45	10 50	11 0
September . . .	10 0	10 20	10 25	10 30	10 32	10 36	10 40	10 45	10 55	10 55
October . . .	9 50	10 0	10 15	10 15	10 15	10 15	10 20	10 15	10 20	10 15
November . . .	9 40	9 55	10 0	10 0	10 0	9 55	9 55	10 0	10 10	10 20
December . . .	9 50	10 0	10 15	10 0	10 0	10 5	10 10	10 10	10 15	10 20

There are a number of local peculiarities in the epoch of the evening maximum, which are stated in the following paragraphs.

(1) At the stations of Belgaum, Poona and Deesa the evening maximum occurs earlier than the normal for stations in the same latitude, as shown below :—

Month.	Amount of acceleration of the evening maximum of pressure at		
	Belgaum.	Poona.	Deesa.
	Min.	Min.	Min.
January	26	13	25
February	39	19	32
March	38	17	24
April	46	29	37
May	22	15	10
June	17	9	10
July	20	28	15
August	33	34	30
September	29	46	8
October	34	29	22
November	14	14	0
December	31	3	9
Mean .	29	21	19

The data indicate that the acceleration, due probably to peculiarities of local conditions, averages 29 minutes for Belgaum, 21 minutes for Poona and 19 minutes for Deesa.

(2) The evening maximum occurs earlier at the coast stations than at neighbouring stations in the interior in approximately the same latitude. The following gives data showing the amount of acceleration (acceleration being denoted by the negative sign and retardation by the positive):—

Month.	Difference between the epochs of evening maximum of pressure.					
	Trivandrum *minus* Trichinopoly.	Madras *minus* Trichinopoly.	Rangoon *minus* Calcutta.	Chittagong *minus* Calcutta.	Kurrachee *minus* Jaipur.	Aden *minus* Beary.
	Min.	Min.	Min.	Min.	Min.	Min.
January	−12	−10	+18	+26	+ 1	−11
February	−24	−18	−11	+ 3	+21	−24
March	−31	−19	−12	−14	+10	− 1
April	−22	− 4	+11	−12	+ 5	−33
May	−18	+ 3	−15	+35	−10	−37
June	−27	−10	−32	− 6	−12	−43
July	−20	+10	−21	− 7	−10	+ 6
August	−27	− 3	− 2	+15	−13	−19
September	−29	− 9	+ 7	+22	+ 8	−27
October	−24	−10	+35	+23	− 2	−29
November	−23	−17	+ 3	+ 7	+ 3	−39
December	−21	−28	+ 2	+10	+12	−17
Mean	−23	−10	− 1	+ 9	+ 2	−23

The acceleration is very clearly exhibited at Trivandrum, Madras and Aden. Chittagong is the only marked exception.

(3) The evening maximum, as a rule, occurs earlier at the stations on the crest of hills than at the neighbouring plain stations. The following gives data in illustration (a negative sign indicating acceleration of epoch):—

Month.	Difference between the epochs of evening maximum of pressure.			
	Agustia *minus* Trichinoply.	Agustia *minus* Trivandrum.	Simla *minus* mean of Roorkee and Lahore.	Pachmarhi *minus* mean of Jubbulpore and Nagpur.
	Min.	Min.	Min.	Min.
January	−36	−24	−21	−15
February	−38	−14	−23	−20
March	−42	−11	−32	−18
April	−37	−15	−41	−30
May	−30	−12	−32	−18
June	−41	−14	−50	+ 4

Month.	Difference between the epochs of evening maximum of pressure.			
	Agustia *minus* Trichinopoly.	Agustia *minus* Trivandrum.	Simla *minus* mean of Roorkee and Lahore.	Pachmarhi *minus* mean of Jubbulpore and Nagpur.
	Min.	Min.	Min.	Min.
July	—22	— 2	—25	—11
August	—23	+ 4	—29	—16
September	—31	— 2	—61	— 8
October	—30	— 6	—42	— 9
November	—34	—11	—30	—25
December	—33	—12	—36	—27
Mean	—33	—10	—35	—16

The acceleration is marked at all these stations, and is greatest in actual amount at Simla.

(4) The evening maximum generally occurs later at mountain valley stations than at neighbouring plains stations in the same latitude, as shown below :—

Month.	Approximate amount of retardation of epoch of evening maximum of pressure at		
	Goalpara.	Sibsagar.	Srinagar.
January	+11	+11	+17
February	+ 6	—19	+15
March	— 3	—30	0
April	+22	—13	— 3
May	— 9	—16	+35
June	— 1	—32	+27
July	—20	—10	+35
August	+ 4	—17	+67
September	+11	—22	+52
October	+ 9	+ 5	+118
November	+47	+17	+66
December	+34	+11	+45
Mean of year	+ 9	—10	+40

The retardation due to position in valleys is strongly exhibited at Srinagar and slightly at Goalpara. Sibsagar is an exception to the rule during eight months of the year.

The following summarises the results of the discussion on the chief features of the epoch of the evening maximum.—

(*1*) *The evening maximum is later in ten months in Extra Tropical than in Tropical India.*

On the average of the year it occurs at 10-19 P.M. in Tropical India and 10·31 P.M. in Extra-Tropical India or 12 minutes later in the latter than the former area.

(2) The differences are largest during the south-west monsoon period from June to September when they average 20 minutes.

(3) The evening maximum occurs earliest in both Tropical and Extra-Tropical India in November (10-9 P.M. on the mean of the whole of India) and latest in Tropical India in May (10-39 P.M.) and in Extra-Tropical India in June and July (10-47 P.M.). The epoch is hence retarded during the period of increasing heat from January to May or June, and accelerated during the period of decreasing temperature from September to November or December.

(4) It is slightly retarded with increasing latitude during the whole year. The retardation being greatest in the south-west monsoon period.

(5) The evening maximum is considerably accelerated at Belgaum, Poona and Deesa, by amounts averaging 23 minutes for the whole year. The acceleration is greatest in the dry season from February to May and is moderate in amount in the rains.

(6) It is also retarded in valleys and more especially in deep, elevated and well-defined mountain valleys (e.g. at Leh and Srinagar).

(7) It is slightly accelerated at the majority of the coast stations as compared with the neighbouring stations in the interior. The only important exception is Chittagong.

(8) It is considerably accelerated at stations on the crest of mountain ranges, and is clearly shown at all these stations in India, viz., Agustia, Pachmarhi and Simla.

General summary of preceding discussion.—The following summarizes the more important results of the preceding discussion :—

(1) The early morning minimum occurs earliest in the day in May or June and latest in December or January. The range of variation is large, amounting to 1 hour 22 minutes in the monthly means for Extra-Tropical India and 31 minutes for Tropical India. It occurs, on the average of the year, only 2 minutes earlier in Extra-Tropical than in Tropical India.

(2) The morning maximum is earliest in the day in June and latest in February, and hence at practically the same periods of the year as the corresponding phase of the early morning minimum. The annual range of variation is only 30 minutes for Extra-Tropical India and 24 minutes for Tropical India.

(3) The afternoon minimum occurs earliest in the day in November or December and latest in May or June. The annual variation in Extra-Tropical India is 1 hour 12 minutes and in Tropical India 47 minutes.

(4) The evening maximum is earliest in November to January and latest in May or June. The annual range of variation of its mean epoch for Extra-Tropical and Tropical India is 38 minutes.

(5) The epochs of the maximum phases are much less variable than those of the minimum phases, the annual range of variation of the former in Extra-Tropical India being little more than a third of that of the latter.

(6) The variations of the morning phases are inverse or opposite to those of the afternoon or evening phases, *i.e.*, the epochs of the former are accelerated when the latter are retarded.

(7) The critical epochs of these phases occur about the time of longest and shortest days, and are evidently related to the period or duration of sunshine, as early morning phases accompany late afternoon and evening phases (the amounts

of acceleration and retardation being nearly equal). The following gives data in illustration :—

		Variation from annual mean of			
		Morning minimum.	Afternoon minimum.	Morning maximum.	Afternoon maximum.
		Min.	Min.	Min.	Min.
Extra-Tropical India	January	+47	−38	+ 7	−20
	June	−23	+29	−14	+16
Tropical India	January	+13	−16	+ 7	− 5
	June	+4	+18	− 9	+ 7

(8) The annual range of variation in the epochs of the minima phases is considerably greater than that of the maxima epochs. The range is considerably greater for the minima in Extra-Tropical India than in Tropical India, whereas that of the maxima is practically identical in amount in both areas. The following table gives comparative data in illustration :—

	Amount of absolute variation in			
	Extra-Tropical India.		Tropical India.	
	H.	M.	H.	M.
Morning minimum	1	22	0	31
„ maximum	0	30	0	24
Afternoon minimum	1	13	0	47
„ maximum	0	38	0	38

Whence, more especially in Extra-Tropical India, the epochs of the minima values are much more variable than those of the maxima, and the annual variation or range of the minima corresponds closely to that of the length of the day.

(9) There are a number of important local peculiarities in the occurrence of the maxima and minima phases of the diurnal oscillation of pressure of which the most important are given in the following five paragraphs :—

(*a*) The epochs generally occur earlier at coast stations than at neighbouring stations in the interior. The following gives the mean acceleration in different seasons for the coast stations of Trivandrum, Madras, Rangoon and Kurrachee :—

	January and February.	March to May.	June to September.	October to December.	Year.
	Min.	Min.	Min.	Min.	Min.
Morning minimum	− 1	− 4	− 6	+ 5	− 2
„ maximum	+ 7	+ 3	+ 3	+ 9	+ 6
Afternoon minimum	+22	+18	+ 5	+23	+17
„ maximum	+ 5	+ 8	+ 5	+ 6	+ 6

(*b*) Position in mountain valleys accelerates the epochs of the morning maximum and the afternoon minimum and evening maximum. The following gives the mean amount of the acceleration for the stations of Sibsagar, Goalpara and Srinagar :—

	January and February.	March to May.	June to September.	October to December.	Year.
	Min.	Min.	Min.	Min.	Min.
Morning minimum	—10	—15	—10	—24	—15
" maximum	22	28	23	14	22
Afternoon minimum	20	16	11	— 2	11
" maximum	— 2	8	11	—20	— 1

(*c*) The morning epochs are retarded and the afternoon epochs accelerated at stations on mountain crests. The following gives mean data for Agustia, Pachmarhi and Simla :—

	January and February.	March to May.	June to September.	October to December.	Year.
	Min.	Min.	Min.	Min.	Min.
Morning minimum	—17	—18	—14	—18	—17
" maximum	—12	—36	—39	—15	—28
Afternoon minimum	8	9	0	15	8
" maximum	22	27	13	29	23

(*d*) All the epochs are accelerated at the stations of Belgaum, Poona and Deesa situated within a short distance (the limit of the extension of the land and sea breezes) from the west coast. The following gives data for these stations in illustration :—

	January and February.	March to May.	June to September.	October to December.	Year.
	Min.	Min.	Min.	Min.	Min.
Morning minimum	11	13	3	14	10
" maximum	10	13	6	14	11
Afternoon minimum	23	29	12	16	20
" maximum	26	26	23	17	23

(*e*) The epochs are generally retarded at Cuttack and Calcutta, situated about the same distance from the north coast of the Bay of Bengal as the stations in the preceding paragraph are from the west coast of the Arabian Sea.

The actual amplitudes of the night and day oscillations.— There are a large number of interesting features in this element of the diurnal oscillation,

The following is a statement of the more important :—

(1) The amplitude of the night oscillation is, on the whole, greatest at the coast stations in Southern India and decreases generally with increasing latitude at both coast and interior stations, as is shown by the following data for the mean day of the year and for the months of April and August, the months most typical of the dry and wet seasons :—

Station.	Latitude North.		Amplitude of night oscillation.		
			Mean day of the year.	April.	August.
	°	′	″	″	″
Trivandrum	8	31	·0651	·0693	·0630
Trichinopoly	10	50	·0574	·0499	·0522
Madras	13	4	·0618	·0527	·0468
Bellary	15	9	·0402	·0375	·0420
Belgaum	15	52	·0530	·0504	·0610
Rangoon	16	46	·0416	·0263	·0478
Bombay	18	54	·0510	·0440	·0580
Nagpur	21	9	·0364	·0285	·0452
Calcutta	22	32	·0423	·0412	·0530
Deesa	24	16	·0341	·0305	·0348
Kurrachee	24	47	·0343	·0386	·0381
Allahabad	25	26	·0297	·0319	·0372
Patna	25	37	·0366	·0331	·0407
Jaipur	26	55	·0312	·0306	·0326
Agra	27	10	·0327	·0315	·0305
Roorkee	29	52	·0298	·0374	·0228
Lahore	31	34	·0141	·0224	·0111

The preceding data also indicate that the amplitude decreases with latitude and that the decrease is, however, not a function of latitude only, as it varies very considerably in amount at stations in approximately the same latitude, *e.g.*, Allahabad and Patna, Bombay and Rangoon, Belgaum and Bellary, etc.

(2) The amplitude of the night oscillation is least during the period from April to June

or July immediately antecedent to the rains, when days are longest, temperature and the diurnal range of temperature excessive and the air very dry.

The following statement gives the absolute minimum values of the monthly amplitude of the night oscillation and the epochs of their occurrence:—

Month of smallest amplitude of night oscillation.	Station.	Minimum amplitude of night oscillation.
April	Rangoon	·0263
	Nagpur	·0285
	Bombay	·0440
May	Bellary	·0285
	Pachmarhi	·0281
	Cuttack	·0322
	Dhubri	·0200
	Patna	·0308
	Deesa	·0220
June	Agustia	·0466
	Trichinopoly	·0487
	Belgaum	·0459
	Simla	·0286
	Allahabad	·0239
	Lucknow	·0143
	Agra	·0281
	Roorkee	·0169
	Jaipur	·0256
	Aden	·0137
July	Trivandrum	·0595
	Madras	·0411
	Sibsagar	·0197
	Lahore	·0064
September	Kurrachee	·0289
October	Chittagong	·0341
	Poona	·0341
November	Hazaribagh	·0314
December	Goalpara	·0291
	Calcutta	·0354
	Jubbulpore	·0303

The minimum values do not vary much in Northern and Central India, ranging between ·020″ and ·030″ at the great majority of stations. They increase rapidly southwards

in the Peninsula with decreasing latitude, and range between ·040″ and ·060″ at all stations to the south of at. 16° N. except Bellary. The minimum amplitude is absolutely greatest for Trivandrum (·0595″).

The minimum values are smallest at Aden (·014″), Lucknow (·014″), Roorkee (·017″), and Lahore (·006″).

They are also locally small at the stations in the Assam valley (*viz.*, Dhubri and Sibsagar, each ·020″).

The minimum values are larger at the coast stations than at neighbouring stations in the interior, more especially in Southern India. They are also locally large at Trichinopoly (·049″), Belgaum (·046″), Poona (·034″) and Hazaribagh (·031″) *i.e.*, larger than at the majority of stations in similar latitudes. Local conditions hence appear to be of considerable importance in determining the amplitude of the night oscillation.

(3) The amplitude of the night oscillation is greatest in Northern and Central India (or Extra-Tropical India excluding South Bengal) in the cold-weather and at most stations in February.

The following gives data :—

Month of maximum amplitude of the night oscillation.	Station.	Maximum amplitude of night oscillation.
		″
January	Patna	·0427
February	Lahore	·0308
	Kurrachee	·0409
	Roorkee	·0476
	Agra	·0408
	Jaipur	·0389
	Lucknow	·0361
	Deesa	·0441
	Goalpara	·0408
	Jubbulpore	·0434
	Pachmarhi	·0494
March	Sibsagar	·0328
	Simla	·0480
April	Chittagong	·0527

(4) In the Peninsula and South Bengal the epoch of the maximum night oscillation

varies considerably in its occurrence, but is generally during the rainy season or south-west monsoon period, as is shown below:—

Month of maximum amplitude of the night oscillation.	Station.	Maximum amplitude of night oscillation.
		"
June	Cuttack	·0434
	Rangoon	·0518
July	Poona	·0577
	Allahabad	·0384
	Hazaribagh	·0404
August	Belgaum	·0610
	Calcutta	·0530
	Nagpur	·0452
September	Dhubri	·0436
November	Bellary	·0459
	Trichinopoly	·0674
	Trivandrum	·0725
	Aden	·0517
December	Madras	·0687
	Agustia	·0694

(5) The values of the maximum amplitude of the night oscillation are large in Southern India. They differ little in amount over the Deccan and Central and North-East India, but decrease rapidly northwards in Rajputana, the North-Western Provinces and the Punjab, as is shown by the data in the two preceding paragraphs. The maximum amplitude is greatest at Trivandrum (·0725") and least at Lahore (0308").

The values are larger for the hill stations of Agustia, Simla and Pachmarhi than for the neighbouring plains stations. The magnitude of the night oscillation at these hill stations is a feature of considerable importance.

(6) The day oscillation has its smallest amplitude in the rains and at the great majority of stations in July. The following gives data in illustration:—

Month of smallest amplitude of the day oscillation.	Station.	Minimum amplitude of day oscillation.
		"
June	Sibsagar	·1146
	Rangoon	·0896
	Simla	·0479
July	Agra	·1012
	Jaipur	·0920
	Lucknow	·0905

MONTH OF SMALLEST AMPLITUDE OF THE DAY OSCILLATION.	STATION.	Minimum amplitude of day oscillation.
	Allahabad	·1000
	Deesa	·0996
	Patna	·1045
	Hazaribagh	·0802
	Dhubri	·1152
	Goalpara	·1064
	Calcutta	·0969
	Cuttack	·0907
	Chittagong	·0876
JULY—*contd.*	Jubbulpore	·0920
	Pachmarhi	·0721
	Nagpur	·0954
	Poona	·0653
	Belgaum	·0655
	Bellary	·0978
	Kurrachee	·0693
	Trivandrum	·0824
	Bombay	·0640

The only important exceptions are the following:—

MONTH OF SMALLEST AMPLITUDE OF THE DAY OSCILLATION.	STATION.	Minimum amplitude of day oscillation.
JANUARY	Lahore	·0795
	Leh	·0740
FEBRUARY	Roorkee	·0878
	Agustia	·0586
DECEMBER	Trichinopoly	·1143
	Madras	·1099
	Aden	·1018

The data indicate that there are very considerable differences in the values of the minimum amplitudes of the day oscillation. The largest values are for the Assam stations (Sibsagar and Dhubri) and the smallest for the west coast stations (Bombay and Kurrachee), and for Belgaum and Poona. They are, on the other hand, large at Aden, Madras and Rangoon. Local conditions hence exercise a considerable influence in determining the amplitude of the day oscillation.

(7) The maximum values of the amplitudes of the day oscillation occur over nearly the whole of Northern and Central India in March or April in the beginning or middle of

the hot weather, when the influence of the local sea breezes is least. The following gives data in illustration:—

Month of maximum amplitude of day oscillation.	Station.	Maximum amplitude of day oscillation.
		"
February	Bellary	·1503
	Trivandrum	·1266
	Bombay	·1240
March	Trichinopoly	·1565
	Belgaum	·1365
	Poona	·1513
	Pachmarhi	·0939
	Nagpur	·1539
	Chittagong	·1222
	Allahabad	·1364
	Dhubri	·1591
	Goalpara	·1566
	Calcutta	·1406
	Cuttack	·1521
April	Roorkee	·1146
	Lucknow	·1170
	Agra	1264
	Patna	·1383
	Hazaribagh	·1135
	Rangoon	·1585
	Jubbulpore	·1309
	Madras	·1323
	Agustia	·0809
May	Jaipur	·1172
	Deesa	·1331
June	Lahore	·1062

The following are abnormal:—

Month of maximum amplitude of day oscillation.	Station.	Maximum amplitude of day oscillation.
		"
August	Aden	·1407
September	Leh	·1226
November	Sibsagar	·1434
December	Kurrachee	·1156
	Simla	·0555

The maximum amplitudes of the day oscillation occur in the hottest period of the year, and their epochs range between February in the south of the Peninsula, and May in Rajputana and June in the Punjab.

The maximum amplitudes are locally large in valleys (*e.g.*, Dhubri, Sibsagar, Srinagar and Leh) and small on mountain ridges (*e.g.*, Simla, Agustia and Pachmarhi).

They are also considerably smaller at coast stations than at stations in the interior of India in similar latitudes. They decrease with latitude from about ·160" in the interior of Southern India to ·110" in Upper India (at Lahore and Roorkee).

The following gives a summary of the chief results of the discussion on the amplitudes of the day and night oscillations of pressure in India :—

1. The amplitude of the day oscillation is least in the month of July characterised by much cloud, great humidity, slight to moderate diurnal range of temperature and general uniformity of temperature. The only exceptions are in the dry districts of Upper India and Southern India, where fine dry weather obtains generally during the south-west monsoon period except during the periods of breaks in the rains in Northern India.

2. The minimum values are less at the hill stations than at the neighbouring plains stations.

3. The minimum values are absolutely least at Poona and Belgaum and also at Kurrachee, Bombay and Trivandrum or at the coast stations most exposed to the south west monsoon conditions and currents.

4. The maximum values of the day oscillation occur over the whole of Northern and Central India in March or April, i.e., *in the middle of the hot weather.*

5. The maximum values are large in valleys and small on mountain ridges.

6. The amplitude of the night oscillation is greatest at the coast stations and decreases with distance from the sea and also with latitude.

7. The amplitude of the night oscillation is least during the period from April to June.

8. The amplitude is greatest in Northern and Central India in the cold weather (generally in February) and in the Peninsula and coast districts in the rainy season from June to December.

The periods of the day and night oscillations.—The diurnal variation of the air pressure is by far the most regular of all the diurnal changes of the elements of meteorological observation, so much so that in four days at least out of five the curves obtained by the use of self-registering barographs (mercurial or aneroid) are practically as smooth and regular as those of the monthly, seasonal or annual means given in the memoirs.

The chief difference between the curves for different parts of India and for different seasons is in the relative amplitudes of these two oscillations. Under certain conditions the two oscillations are of approximately equal amplitude. This is usually denominated the maritime type as it occurs chiefly at insular and coast stations and over open seas. In other cases the amplitude of the day oscillation is relatively much larger than that of the night oscillation. In the most exaggerated form of this type (termed the continental type) the night oscillation is practically or actually evanescent. The periods of these oscillations are usually longest when the amplitudes are greatest, and *vice versâ*. Hence the maritime type is characterised by nearly equal periods of the day and night oscillations and the continental type by long day period and short night period.

The diurnal periods of these two oscillations are most satisfactorily defined by the instants of zero variation from the mean of the day and not by the epochs of the maxima and minima values.

The epochs of zero variation defining the night oscillation for the mean day of the year at fourteen typical stations in the interior of India are given in the following table. They are approximate values determined from the curves, and not from the exact numerical data of the diurnal oscillation :—

Station.	Epoch of zero variation on the mean day of the year.		Duration or period of the night oscillation.
	P.M.	A.M.	H. M.
Leh	10·0	6·0	8 0
Lahore	10·0	6·0	8 0
Roorkee	9·0	6·0	9 0
Jaipur	8·45	5·45	9 0
Deesa	8·30	5·30	9 0
Allahabad	8·30	5·30	9 0
Dhubri	8·30	5·30	9 0
Sibsagar	8·40	5·40	9 0
Jubbulpore	8·30	5·45	9 15
Patna	8·30	5·30	9 0
Hazaribagh	8·30	6·20	9 50
Nagpur	8·30	5·30	9 0
Bellary	8·30	5·30	9 0
Trichinopoly	7·45	5·30	9 45

The preceding data indicate that over nearly the whole of the interior of India the period of the night oscillation is almost exactly nine hours. It is less than this at Leh and Lahore, where the oscillation is most markedly of the continental type.

The period is greater at the stations on and near the coasts of India (averaging about ten hours), than at the interior stations, as is shown by a comparison of the data of the preceding and following tables :—

Station.	Epoch of zero variation on the mean day of the year.		Duration or period of the night oscillation.
	P.M.	A.M.	H. M.
Kurrachee	8·20	6·0	9 40
Chittagong	8·20	6·0	9 40
Rangoon	8·20	5·40	9 20
Madras	7·40	5·40	10 0
Bombay	7·40	5·50	10 10
Trivandrum	7·10	6·0	10 50
Calcutta	8·0	6·0	10 0
Belgaum	7·30	6·0	10 30

The data establish that the period of the night oscillation averages almost exactly ten hours at the coast stations; and is actually greatest at the most southerly station (Trivandrum) for which it is nearly eleven hours. As the amplitude of the night oscillation is greatest at the coast stations, it follows that the period of the night oscillation is

greatest at stations where its amplitude (actually and relatively to the day oscillation) is greatest.

The period of the night oscillation also varies considerably throughout the year, the range of variation increasing with latitude. It is least in the hot weather months immediately antecedent to the rains, and is practically constant in amount from June to September over the whole of India. It is greatest in the cold-weather months of December and January.

The following table gives the maximum and minimum periods of the night oscillation at certain stations :—

Area.	Station.	Maximum period of night oscillation.	Month of occurrence.	Minimum period of night oscillation.	Month of occurrence.
		Hours.		Hours.	
Interior (Plains)	Roorkee	11	January and February	7⅓ (?)	June.
	Lahore	11	February	5⅓	July.
	Allahabad	10	January	8⅓	June.
	Calcutta	10	January	8¼	April.
	Jaipur	11	January	7	June.
	Deesa	10¼	February	7	May.
	Nagpur	9¾	January	7⅓	May.
	Belgaum	11	December	9¼	May.
	Bellary	9¼	December	7½	May.
	Trichinopoly	11	December	9	March.
Hills	Pachmarhi	11¼	December	8¾	May.
	Simla	12¼	December	10	June.
	Leh	8¼	January	?	July.
Coast	Rangoon	10¾	June	8	April.
	Chittagong	10	December	8½	May.
	Kurrachee	10¼	December	9	May.

As the period of the day oscillation is complementary to that of the night oscillation it is unnecessary to give separate data for its maximum and minimum values and the epochs of their occurrence.

The following are the chief inferences from the data of the preceding three tables :—

(1) *The period of the night oscillation is a maximum in the cold weather in December and January, almost without exception. The maximum period averages 10⅓ hours in the plains and is longer at the hill stations on mountain ridges than at the neighbouring plain stations.*

(2) *The period of the night oscillation is shortest in May or June. It ranges between 5⅓ and 9¼ hours at the plains stations and averages 7⅔ hours in length.*

(3) *The period of the day oscillation, which is inverse to, or the complement of, the night oscillation, is longest in the months of May or June and shortest in the months of December and January.*

(4) *The period of the night oscillation decreases from the coast districts to the driest districts of the interior in Upper India.*

(5) *The period of the night oscillation depends chiefly upon position with respect to the sea coast and other topographical conditions, such as elevation and position with respect to mountain*

ranges. It also depends partly upon the season, decreasing from December to May or June, and thence increasing from June to December, and also upon the latitude.

(6) The period of the day oscillation depends chiefly upon the season, increasing from December to May or June, and thence decreasing to December over the whole of India. It also depends slightly upon geographical position, elevation and position with respect to the sea coast and mountain ranges.

Ratio of the amplitude of the day oscillation to that of the night oscillation.—The ratio of the amplitude of the day oscillation to that of the night oscillation is less than 3·0 in the coast districts during the greater part of the year as shown below :—

Station.	Least value.	Period in which the ratio is below 3·0.
Rangoon	2·2	May to September.
Chittagong	2·3	March to September.
Madras	1·8	January to December.
Trivandrum . . .	1·7	January to December.
Bombay	2·1	January to December.
Kurrachee	2·3	February to August.
Aden	2·5	October, November and January.

The ratio is, on the other hand, 3·0 or over at all stations in the interior of India during the cold weather, hot weather and retreating south-west monsoon seasons with the exceptions :—

Station.	Least value.	Month of occurence.	Months in which the ratio is below 3·00.
Agra	2·7	January . .	January and February.
Lucknow	2·9	February .	February.
Lahore	2·8	Ditto . .	February.
Jaipur	2·8	Ditto . .	February.
Deesa	2·6	November .	November, January, February, July and August.
Roorkee	1·8	February .	January to March,

i.e., over the whole of North-Western India except the coast and sub-montane districts.

The ratios are greater than 3·0 at the following stations in the interior of India during the rainy season from June to September. The table also gives the maximum value of the ratio during the period and the month of its occurrence :—

Station.	Greatest value.	Month.
Lahore	14·9	July.
Jaipur	4·4	June.
Roorkee	6·8	June.
Agra	4·0	June.
Lucknow	7·4	June.
Sibsagar	6·8	August.

The following table gives the stations at which the ratio is less than 2·0 during a part of the rainy season and the minimum ratio and the month of its occurrence :—

Station.	Least value.	Month.
Bombay	1·2	July.
Madras	1·6	December.
Trivandrum	1·3	June.
Chittagong	1·7	July.
Poona	1·1	July
Belgaum	1·2	July.
Rangoon	1·7	June.
Trichinopoly	1·7	December.
Roorkee	1·8	February.
Kurrachee	1·9	July.
Pachmarhi	1·9	July to February.

The ratio is hence less than 2·0 at the coast stations in the month of June or July, or during the height of the rains and in the part of Southern India represented by Madras and Trichinopoly in December, or during the period of occasional heavy rain due to the retreating south-west monsoon.

It hence follows that the character of the night oscillation depends upon proximity to the sea and position with respect to the direction of the humid currents. It would appear that the Bombay current is more effective in this respect than the Bay current.

The ratios are least in June, July or August (the height of the rains) at the great majority of stations, including those given in the following list :—

Station.	Minimum ratio.	Month.	Station.	Minimum ratio.	Month.
Calcutta . . .	2·1	August.	Rangoon . . .	1·7	June.
Jubbulpore . . .	2·4	July.	Cuttack . . .	2·2	August.
Poona	1·1	July.	Pachmarhi . . .	1·9	July.
Nagpur . . .	2·3	August.	Patna	2·7	July.
Belgaum . . .	1·2	July.	Hazaribagh . . .	2·0	July.
Bellary	2·3	July.	Goalpara . . .	2·9	June.
Chittagong . . .	1·7	July.	Allahabad . . .	2·6	July.

They are least at four stations in Upper India in February, *viz.* :—

Roorkee,	Lucknow,
Lahore,	Jaipur,

and at Agra in January and at Deesa and Aden in November.

It is a noteworthy circumstance that the diurnal oscillation most closely approaches the maritime type of equal amplitude in Upper India in the cold weather during the *months of January and February or during the period of cold-weather storms and rainfall.*

The night oscillation is, relatively to the day oscillation, least important in the dry hot weather, or the ratio of the amplitude of the day oscillation to that of the night oscillation *is greatest in the period, April to July. The maxima ratios also increase generally on pro*ceeding from stations on the coast to stations in the interior in Upper India, as shown below:—

STATION.	Greatest value.	Month.
Hazaribagh	3·4	April.
Goalpara	5·2	April.
Rangoon	6·0	April.
Nagpur	5·3	April.
Jubbulpore	4·1	May.
Patna	4·5	May.
Deesa	6·1	May.
Dhubri	7·3	May.
Sibsagar	6·8	August.
Bellary	5·1	May.
Allahabad	5·0	June.
Lucknow	7·4	June.
Agra	4·0	June.
Jaipur	4·4	June.
Roorkee	6·8	June.
Lahore	14·9	July.

The conditions for maximum amplitudes are inverse in the case of the two oscillations and the maximum of one approximately coincides with the minimum of the other. This is very marked for coast stations and at stations in North-Western India.

The amplitude of the day oscillation is greatest when the days are longest, the temperature and diurnal range of temperature both high and the air very dry. These conditions obtain in the interior.

The continental type is most markedly exhibited at Leh where the night oscillation is evanescent from June to December and is very slightly shown in the remaining months of the year.

The Simla and Srinagar types are abnormal and of great interest. The chief features of the Simla type of diurnal oscillation are that in all months, except June and July, the early morning minimum is deeper and more marked than the afternoon minimum.

Chief features of the epochs and amplitudes of the first four components of the Besselian resolution of the diurnal oscillation of pressure in India.—The inferences in the following paragraphs are based upon a comparison *of the amplitudes and epochs of the first four second compo*nents of the Besselian resolution of the diurnal variation of pressure:—

A. Epochs and amplitudes of the first copmonent.

(1) The amplitude u_1 varies very slightly with latitude. This variation is obscured by other factors. It is, however, very probable it does not exceed ·001" per 2° of latitude in India.

(2) The variations of the amplitude of the first component due to topographical conditions are large. The amplitude is small at stations on the crest of mountain ranges and is large in nearly enclosed valleys (either at low or high elevations), and is intermediate in amount at stations in open plains. The following gives examples for the mean day of the year in illustration :—

	Station.	Amplitude on the mean day of the year.
		″
Stations on mountain crests	Simla	·01004
	Pachmarhi	·01478
	Agumbe	·00523
	Mean	·01002
Stations in valleys	Dhubri	·03532
	Goalpara	·03407
	Leh (High level)	·03374
	Shillong	·03328
	Mean	·03410
Stations in open plains	Calcutta	·02595
	Allahabad	[illegible]
	Lahore	·02[illegible]01
	Nagpur	·02657
	Bellary	·02354
	Mean	·02531

Srinagar, in the Kashmir Valley, appears to be an exception to the statement, as the amplitude of the first component for the mean day of the year is only ·02117″.

(3) The amplitude also varies considerably at neighbouring stations in similar latitudes, apparently depending upon position with respect to the sea mountain ranges, and other topographical conditions, and also perhaps upon meteorological conditions, such as amount of cloud, etc. A reference to Table CXIV, page 308, which gives the monthly values of the amplitudes for all stations, will confirm this.

(4) The epochs of the maximum and minimum monthly values of the first component in its diurnal variation are slightly later with increasing latitude in India, the increase for the mean day of the year being very approximately

seven minutes per degree of latitude. The following gives the mean maximum epochs in different latitudes for the mean day of the year:—

Latitude, North.	Calculated maximum epoch of the first component on the mean day of the year.
	A. M.
14°	6 23
16°	6 37
18°	6 51
20°	7 5
22°	7 19
24°	7 33
26°	7 47
28°	8 1
30°	8 15
32°	8 29

(5) The epochs of the maximum and minimum are slightly retarded with increasing latitude in all months of the year. In most months the retardation ranges between six and eight minutes and averages almost exactly seven minutes per degree of latitude. In the month of September it is ten minutes per degree of latitude. The following gives data corresponding to that of the preceding paragraph for six alternate months of the year:—

Latitude, North.	Calculated maximum epoch of the first component in					
	January.	March.	May.	July.	September.	November.
	A. M.	A. M.	A. M.	A. M.	A. M.	A. M.
14° . . .	6 24	6 46	6 30	6 18	5 20	6 13
16° . . .	6 40	7 0	6 44	6 30	5 40	6 27
18° . . .	6 56	7 14	6 58	6 42	6 0	6 41
20° . . .	7 12	7 28	7 12	6 54	6 20	6 55
22° . . .	7 28	7 42	7 26	7 6	6 40	7 9
24° . . .	7 44	7 56	7 40	7 18	7 0	7 23
26° . . .	8 0	8 10	7 54	7 30	7 20	7 37
28° . . .	8 16	8 24	8 8	7 42	7 40	7 51
30° . . .	8 32	8 38	8 22	7 54	8 0	8 5
32° . . .	8 48	8 52	8 36	8 6	8 20	8 19

(6) The epoch of the maximum is generally earlier at the coast stations than at stations in corresponding latitudes in the interior. The following table gives the epochs of the maximum for the five coast stations of Trivandrum;

Madras, Rangoon, Chittagong and Kurrachee in the six months of January, March, May, July, September and November.

Station.	Maximum epoch of u_1 in					
	January.	March.	May.	July.	September.	November.
	H. M.	H. M.	H. M.	H. M.	H. M.	H. M.
Trivandrum .	4 59	5 3	5 12	3 51	4 14	3 53
Madras . .	7 8	6 51	5 40	5 32	5 18	6 7
Rangoon .	6 15	6 55	6 40	6 6	6 8	5 33
Chittagong .	6 51	8 15	7 41	5 23	5 38	6 0
Kurrachee .	7 22	8 4	8 7	5 36	6 32	6 55

In the following table are given the differences between the maximum epochs of the five coast stations, for which data are given in the preceding table, from the corresponding epochs for the same latitudes in the interior. A negative sign prefixed to the time amount indicates that the epoch is earlier at the coast station than in the interior at the same latitude and a positive sign that it is later :—

Station.	Approximate Lat. North.	Variation of epoch from normal in						
		January.	March.	May.	July.	September.	November.	Mean day of year.
		H. M.	H. M.	H. M.	H. M.	H. M.	H. M.	H. M.
Trivandrum	8	−0 37	−1 1	−0 36	−1 51	−0 6	−1 38	−1 5
Madras	13	+0 52	+0 2	−0 54	−0 33	+0 15	+0 15	−0 17
Rangoon	17	−0 33	−0 12	−0 11	−0 30	+0 18	−1 0	−0 22
Chittagong	22½	−0 32	+0 31	+0 13	−1 45	−1 5	−1 11	−0 32
Kurrachee	25	−0 32	+0 1	+0 29	−1 45	−0 37	−0 35	−0 35

(7) The epochs of the maximum values of the first component are accelerated in all months at stations in deep and well-defined valleys at low or high altitudes. The two following tables give data in illustration for Leh, Srinagar, Sibsagar, Goalpara and Dhubri, all of which come within this category. The data are obtained in the same manner as the data in the two preceding tables. A negative sign in the second table indicates relative acceleration and a positive sign retardation :—

Station.	Maximum epoch of u_1 in						
	January.	March.	May.	July.	September.	November.	Mean day of year.
	H. M.	H. M.	H. M.	H. M.	H. M.	H. M.	H. M.
Leh .	7 18	6 57	5 41	6 35	6 45	6 33	6 33
Srinagar .	12 11	8 10	6 38	7 52	6 56	7 15	7 23
Sibsagar .	6 29	7 10	7 27	6 58	6 42	6 36	6 35
Goalpara .	6 37	7 13	7 35	6 15	6 13	6 49	6 57
Dhubri .	6 46	7 2	7 31	5 48	6 15	6 18	6 38

Station.	Variation of epoch from normal in						
	January.	March.	May.	July.	September.	November.	Mean day of year.
	H. M.	H. M.	H. M.	H. M.	H. M.	H. M.	H. M.
Leh	−1 46	−2 7	−3 9	−1 43	−2 0	−2 0	−2 10
Srinagar	+3 7	−0 56	−2 12	−0 46	−1 44	−1 18	−1 20
Sibsagar	−1 29	−1 7	−0 34	−0 38	−0 48	−1 8	−0 59
Goalpara	−1 23	−0 57	−0 1	−1 12	−1 8	−0 48	−0 50
Dhubri	−1 14	−1 8	−0 23	−1 49	−1 5	−1 19	−1 9

The data indicate that the acceleration in the Assam valley is on the mean day of year almost exactly one hour. At Leh, in the upper valley of the Indus, it averages $2\frac{1}{6}$ hours, and at Srinagar in the Kashmir Valley $1\frac{1}{3}$ hours.

(8) The epochs of the maxima and minima values of the first component are considerably retarded at stations on the crests of mountain ranges, as is shown by the following data for Agustia, Simla and Pachmarhi :—

Station.	Maximum epoch of u_1 in						
	January.	March.	May.	July.	September.	November.	Mean day of year.
	H. M.	H. M.	H. M.	H. M.	H. M.	H. M.	H. M.
Simla	12 20	14 2	11 21	8 46	11 9	11 11	11 38
Pachmarhi	8 50	8 49	8 8	7 57	7 32	8 50	8 28
Agustia	12 28	11 55	7 11	8 34	7 44	12 9	9 55

Station.	Variation of epoch form normal in						
	January.	March.	May.	July.	September.	November.	Mean day of year.
	H. M.	H. M.	H. M.	H. M.	H. M.	H. M.	H. M.
Simla	+3 40	+5 17	+2 52	+0 46	+2 59	+2 59	+3 16
Pachmarhi	+1 18	+1 4	+0 39	+0 48	+0 47	+1 38	+1 6
Agustia	+6 46	+5 46	+1 16	+2 46	+3 14	+6 31	+4 7

The data indicate that the epoch is considerably retarded at these hill stations. The amount of the retardation differs largely with the season, more especially at Simla and Agustia. The retardation is smallest in the rains and greatest in the cold dry weather. It averages 4 hours for Agustia, $3\frac{1}{4}$ hours for Simla and 1 hour for Pachmahri.

(9) The epochs of the maximum and minimum phases of the first component are latest in Extra-Tropical India in February and are earliest in the day in July. The epochs are practically constant throughout the rainy season. The mean range of variation of the epochs during the year at these stations

is 1 hour 18 minutes and varies between 1 hour 5 minutes (for Roorkee) and 3 hours 24 minutes (for Chittagong).

(10) The maximum and minimum epochs are also latest in February in the Peninsula or Tropical India and earliest in June. The mean annual range of variation of the epochs is 1 hour 28 minutes, varying between 1 hour 16 minutes (for Cuttack) and 3 hours 34 minutes (for Poona).

The following is summary of the more important features of the first component:—

(1) *The amplitude decreases slowly with latitude.*

(2) *The amplitude varies largely at low level stations in India, and is largely dependent upon local geographical and meteorological conditions.*

(3) *The amplitude is small at stations on mountain ranges and large at stations in mountain valleys.*

(4) *The epochs of the maximum and minimum are slightly retarded with increasing latitude in all months.*

(5) *The critical epochs are generally earlier at the coast stations than at plains stations in the interior in similar latitudes.*

(6) *The critical epochs are largely accelerated at valley stations and are retarded at stations on mountain ridges.*

(7) *The epochs are earliest in the day in February and latest in the day in June or July.*

The second component.—The second component is the most important of the four elements or components of the Besselian resolution of the diurnal oscillation of pressure. It is the constituent of largest amplitude and of least variation with season, or with local conditions.

The following is an analysis of the more important and characteristic features of the epoch and amplitude of this component in India :—

(1) The epoch of the maximum values of the second component is later with increasing latitude, the rate of retardation for the mean day of the year being very approximately 2½ minutes per degree of latitude in India between Lat. 18° N. and Lat. 32° N. To the south of Lat. 18° N. it varies slightly and irregularly with latitude. The following table gives the mean epochs (A.M. and P.M) of the maxima values for different latitudes between 18° and 32° :—

Latitude, North.	Calculated maximum epochs of the second component in the mean day of the year.	
	(A.M. and P.M.)	
18°	9	40
20°	9	45
22°	9	50
24°	9	55
26°	10	0
28°	10	5
30°	10	10
32°	10	15

(2) The epochs of the maximum values of the second component are retarded with increasing latitude in every month of the year, the rate of retardation being practically the same throughout the year, and averaging $2\frac{1}{2}$ minutes per degree of latitude. The following table gives maximum epochs in different latitudes in six alternate months of the year:—

Latitude, North.	Calculated maximum epoch of the second component in					
	January.	March.	May.	July.	September.	November.
	A.M. and P.M.	A.M. and P.M.	A.M. and P.M.	A.M. and P.M.	A.M. and P.M.	A.M. and P.M.
16°	9 34	9 36	9 36	9 55	9 36	9 15
18°	9 40	9 42	9 41	10 0	9 40	9 20
20°	9 46	9 48	9 46	10 5	9 44	9 25
22°	9 52	9 54	9 51	10 10	9 48	9 30
24°	9 58	10 0	9 56	10 15	9 52	9 35
26°	10 4	10 6	10 1	10 20	9 56	9 40
28°	10 10	10 12	10 6	10 25	10 0	9 45
30°	10 16	10 18	10 11	10 30	10 4	9 50
32°	10 22	10 24	10 16	10 35	10 8	9 55

(3) The epochs of the maximum phases of the second component are earliest in Bengal, Assam, Bihar, Rajputana and the eastern half of the North-Western Provinces in the month of November and in the western half of the North-Western Provinces, Punjab and Sind in the month of October. They are, on the other hand, latest in the day in the month of July at the majority of stations in these areas. The following gives the mean epochs and range for each month of the year for Extra-Tropical India:—

Month.	Extra-Tropical India.		
	Mean epoch of maximum A.M. and P.M.		Range of variation.
	H.	M.	Min.
January	9	58	41
February	10	7	43
March	10	7	39
April	10	6	41
May	10	6	37
June	10	11	34
July	10	17	32
August	10	12	33
September	10	1	25
October	9	46	34
November	9	44	35
December	9	51	41
Year	10	2	37

The mean range of variation in Extra-Tropical India is hence 37 minutes. It is least at Sibsagar (20 minutes) and greatest at Calcutta (43 minutes), Roorkee (43 minutes), Kurrachee and Srinagar (each 42 minutes), Deesa, Lahore and Dhubri (each 40 minutes). The range is also least in the rains when it is practically uniform in amount at all stations in Extra-Tropical India averaging 36 minutes.

(4) In Tropical India the epochs of the maximum values of the second component are earliest in November (9·28 A.M. and P.M.) and latest in the rains in July (9·58 A.M. and P.M.). The mean range of variation is hence 30 minutes. The following gives data for comparison:—

Month.	Tropical India.		
	Mean epoch of maximum A.M. and P.M.		Range of variation.
	H.	M.	Min.
January	9	42	22
February	9	53	26
March	9	50	25
April	9	47	32
May	9	47	29
June	9	54	27
July	9	58	23
August	9	55	33
September	9	41	33
October	9	29	27
November	9	28	25
December	9	36	25
Year	9	45	23

(5) The amplitude of the second component presents considerable differences in different parts of India.

The monthly values which are given in Table CXV at the end of this section for convenient reference have, in the great majority of the cases, two maxima and minima in the course of the year. The absolute or primary maximum and minimum are very strongly

marked, but the secondary maximum and minimum are very feebly exhibited and are absent at the following stations:—

Area.	Station.
Tropical India	Trivandrum.
	Bombay.
	Poona.
	Cuttack.
Extra-Tropical India	Sibsagar.
	Goalpara.
	Agra.
	Kurrachee.
	Srinagar.

Most of these stations are on or in the immediate neighbourhood of the sea coast or in the damp Assam and Kashmir Valleys.

(6) The absolute maximum occurs on the mean of the whole of India in the month of March. The amplitude differs very slightly in amount in February and March. The following gives data of the absolute maximum amplitudes at stations in Tropical India:—

Month of absolute maximum amplitude.	Station.	Absolute maximum amplitude.
		"
February	Trivandrum	·04775
	Trichinopoly	·05223
	Bellary	·04575
	Bombay	·04400
March	Madras	·04571
	Rangoon	·04531
	Belgaum	·04756
	Poona	·04870
	Nagpur	·04631
	Cuttack	·04695
	Pachmarhi	·03615
	Jubbulpore	·04063
April	Chittagong	·04085

Hence the maximum amplitude occurs at four stations in February, at eight in March, and at one (*viz.*, Chittagong, a station which presents several abnormal pressure features) in April. If it be assumed that the mean value for any month corresponded closely to the daily value for the middle of the month the epoch of the absolute maximum amplitude in the Peninsula or Tropical India hence occurs about the end of the first or beginning of second week of March. The maximum values also indicate or suggest that the amplitudes decrease slightly northwards in the Peninsula, and are somewhat greater for the interior than the coast stations.

The following gives corresponding data of the epoch of the absolute maximum at stations in Extra Tropical India:—

Month of absolute maximum amplitude.	Station.	Absolute maximum amplitude.
		"
December	Sibsagar	·04237
January	Lucknow	·03635
	Srinagar	·03174
February	Deesa	·04092
	Kurrachee	·03730
	Agra	·03900
	Lahore	·02882
March	Calcutta	·04510
	Goalpara	·04639
	Dhubri	·04615
	Hazaribagh	·03727
	Patna	·04165
	Allahabad	·03995
	Jaipur	·03683
	Simla	·02400
	Leh	·02272
April	Roorkee	·03553

The date of occurrence of the absolute maximum amplitude is more variable in Extra-Tropical than in Tropical India. It occurs at one station in December, at two in January, four in February, nine in March and one in April, and on the mean of all at the end of the fourth week of February. It hence is not only more variable in Extra-Tropical India than in Tropical India, but occurs slightly earlier (about a fortnight) on the average of all stations.

(7) The absolute minimum occurs almost without exception in the month of June or

The following gives the epochs and amplitudes of the minimum values at stations in Tropical India:—

Month of absolute minimum amplitude.	Station.	Absolute minimum amplitude.
June	Augustia	·02658
	Trichinopoly	·04038
	Aden	·02917
	Belgaum	·02928
	Chittagong	·03197
July	Trivandrum	·03526
	Madras	·03831
	Bombay	·02900
	Rangoon	·03338
	Bellary	·03429
	Poona	·03043
	Nagpur	·03227
	Pachmarhi	·02665
	Cuttack	·03105
	Jubbulpore	·03129

It hence occurs at ten stations in July and at five in June and on the mean of all at the beginning of the second week of July.

The following gives corresponding data for stations in Extra-Tropical India:-

Month of absolute minimum amplitude.	Station.	Absolute minimum amplitude.
June	Dhubri	·03406
	Hazaribagh	·02859
	Allahabad	·03228
	Lucknow	·02635
	Roorkee	·02712
	Kurrachee	·02386
	Simla	·01789
	Srinagar	·02056
	Leh	·01646
July	Calcutta	·03483
	Sibsagar	·03344
	Patna	·03437
	Agra	·03005
	Jaipur	·02863
	Deesa	·03210
	Lahore	·02152

Hence the absolute minimum amplitudes occur at nine stations in June and at seven in July, or on the mean of all at the end of June, and hence about a fortnight earlier than in Tropical India. The data show also that the amplitudes are less at coast stations than at corresponding stations in the interior and that they decrease with increasing latitude.

(8) As already stated, the secondary maximum and minimum values are very feebly marked, and are absent in nine out of 32 stations.

The following gives the epochs and amplitudes of the secondary maximum at nine stations in Tropical India:—

Month of secondary maximum amplitude.	Station.	Secondary maximum amplitude.
		"
October	Madras	·04474
	Trichinopoly	·04980
	Rangoon	·04108
	Belgaum	·04303
	Nagpur	·04034
	Jubbulpore	·03734
November	Aden	·04281
	Pachmarhi	·03414
December	Bellary	·04566

The data indicate that the secondary maximum occurs in October in the Peninsula. The only exceptions are Bellary and the hill station of Pachmarhi. The mean value of the secondary maximum is ·04310.

The following gives corresponding data for Extra Tropical India:—

Month of secondary maximum amplitude.	Station.	Secondary maximum amplitude.
		"
September	Calcutta	·04152
	Dhubri	·04168
	Hazaribagh	·03537
	Patna	·03928
	Allahabad	·03679
	Lucknow	·03141
	Leh	·02275
October	Jaipur	·03346
	Lahore	·02613
November	Deesa	·03950
	Roorkee	·03417

The secondary maximum occurs in September at most stations in Extra-Tropical India, but is delayed until October or November in North-Western-India, represented by the stations of Roorkee, Lahore, Jaipur and Deesa. This epoch is hence, as a rule, a month earlier in Extra-Tropical than in Tropical India.

(9) The following gives the epochs and amplitudes of the secondary minimum at eight stations in Tropical India :—

Month of secondary minimum amplitude.	Station.	Secondary minimum amplitude.
		"
November	Madras	·04384
	Rangoon	·03880
	Bellary	·04516
	Belgaum	·04282
	Nagpur	·03987
	Jubbulpore	·03605
December	Pachmarhi	·03323
	Aden	·03417

The secondary minimum occurs in November in Tropical India, and hence in the month following the secondary maximum. This latter relation moreover obtains for the two exceptions to the occurrence of the secondary maximum in October. The mean value of the secondary minima values in Tropical India is ·04109", and hence only ·00205" less than the mean secondary maximum value in that area. This variation is hence very small, its amplitude at most stations in that area being less than two thousandths of an inch.

The following gives corresponding data for Extra-Tropical India :—

Month of secondary minimum amplitude.	Station.	Secondary minimum amplitude.
		"
October	Calcutta	·03913
	Dhubri	·04085
	Patna	·03788
	Lucknow	·03103
November	Hazaribagh	·03214
	Allahabad	·03546
	Lahore	·02533
	Jaipur	·03291
December	Deesa	·03876
	Roorkee	·03226

The secondary minimum occurs in either October or November at the great majority of stations in Extra-Tropical India, and, as a rule, in the month following the epoch of the secondary maximum.

(10) The following table gives the mean monthly values of the amplitude of the second component for six groups of stations, and as a summary for convenient reference of the data in table:—

Area.	Mean monthly values of the amplitude of the second component in											
	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.
	"	"	"	"	"	"	"	"	"	"	"	"
Extra-Tropical India, Inland .	·03722	·03851	·03869	·03720	·03400	·03113	·02928	·03253	·03535	·03538	·03606	·03633
Extra-Tropical India, Coast .	03854	·04040	·04025	·03875	·03449	·03032	·03145	·03389	·03642	·03563	·03749	·03804
Tropical India, Inland . .	·04532	·04749	·04767	·04408	·04058	·03397	03349	·03761	·04189	·04431	·04371	·04371
Tropical India, Coast . .	·04414	·04568	·04548	·04317	·03894	·03532	·03341	·03669	·04022	·04205	·04259	·04314
Mountain crest stations . .	·02531	·02608	·02837	·03043	·02669	·02224	·02372	·02573	·02697	·02828	·02602	·02891
Mountain valley stations . .	·02866	·02789	·02937	·02705	·02410	·02176	·02287	·02351	·02769	·02769	·02821	·02764

The preceding data show closely the chief features of the annual variation of the amplitude of the second component. The absolute maximum occurs generally in March and the absolute minimum in July in the plains and in June at the mountain stations. The secondary maximum and minimum are very feebly marked.

(11) The following table gives the mean epochs of the first maximum phase of the second component in its diurnal variation:—

Area.	Mean epoch of the first maximum phase of the second component in											
	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.
	H. M.	H. M.	H. M.	H. M	H. M.	H. M.	H. M	H. M.	H. M.	H. M.	H. M.	H. M.
Extra-Tropical India, Inland .	9 59	10 7	10 7	10 6	10 6	10 11	10 17	10 12	10 2	9 47	9 46	9 53
Extra-Tropical India, Coast .	9 53	10 8	10 7	10 6	10 8	10 17	10 15	10 9	9 57	9 39	9 36	9 43
Tropical India, Inland . .	9 43	9 55	9 52	9 49	9 48	9 56	10 0	9 56	9 42	9 30	9 30	9 39
Tropical India, Coast . .	9 40	9 48	9 46	9 45	9 47	9 52	9 57	9 51	9 39	9 24	9 23	9 30
Mount crest stations . .	10 3	10 17	10 15	10 8	10 4	10 9	10 24	10 17	10 2	9 47	9 44	9 51
Mountain valley stations . .	10 0	10 9	10 8	10 1	10 4	10 3	10 19	10 15	9 59	9 55	9 53	9 56

The epoch of the first maximum phase is earliest in October or November, and latest in July at all stations almost without exception. The earliest epoch (in November) averages 9·44 A.M. in Extra-Tropical India and 9·28 A.M. in Tropical India, and the latest

epoch (in July) is 10-17 A.M. in Extra-Tropical India and 9-58 A.M. in Tropical India. The range of variation is 33 minutes in Extra-Tropical India and 30 minutes in Tropical India.

The local variations in the epoch of the maximum phase are small. It is, on the average of the year, 8 minutes later at Pachmarhi than at Nagpur, 14 minutes later at Simla than at Roorkee, and 14 minutes later at Augustia than at Trivandrum. It is, on the other hand, slightly earlier than the normal at Leh and Sibsagar.

There is hence a slight retardation of the phases at stations on the crests of mountain ridges and a very slight acceleration in mountain valleys.

(12) The following table gives the epochs of the first maximum phase of the second component in its diurnal variation in different latitudes in India for the months of January April, July, September and November :—

Latitude N.	Mean epoch of the first maximum phase of the second component in				
	January	April.	July.	September.	November.
°	A.M.	A.M.	A.M.	A.M.	A.M.
10	9 30	9 45	9 50	9 35	9 2
15	9 40	9 50	9 55	9 40	9 22
20	9 45	9 55	10 5	9 45	9 25
22½	9 50	10 0	10 10	9 50	9 30
25	9 55	10 5	10 15	9 55	9 40
27½	10 5	10 10	10 20	10 5	9 45
30	10 10	10 15	10 30	10 5	9 50
32	10 15	10 20	10 35	10 5	9 55

(13) The amplitude of the second component decreases with elevation and approximately proportional to the decrease of pressure. The following gives data for two groups of stations, *viz.*, Agustia and Trivandrum, and Simla and Roorkee.

Month.	Ratio of values of U_2 for Agustia and Trivandrum.	Ratio of actual pressure for Agustia and Trivandrum.	Ratio of values of U_2 for Simla and Roorkee.	Ratio of actual pressure for Simla and Roorkee.
January	·64	·81	·62	·80
February	·62	·81	·67	·80
March	·69	·81	·72	·80
April	·81	·81	·67	·80
May	·84	·81	·63	·80
June	·74	·81	·66	·80
July	·79	·81	·71	·80
August	·79	·81	·69	·80
September	·79	·81	·65	·80
October	·77	·81	·67	·80
November	·68	·81	·62	·80
December	·75	·81	·73	·80
Year	·73	·81	·67	·80

The data show that there is a considerable variation in the ratios of the amplitudes at high and low levels, independent of the actual pressure.

The following table gives data for Leh and Srinagar (compared with Lahore) similar to that in the preceeding table of page 292 :—

Month.	Ratio of values U_2 for Leh and Lahore.	Ratio of actual pressure for Leh and Lahore.	Ratio of values U_2 for Srinagar and Lahore.	Ratio of actual pressure for Srinagar and Lahore.
January	·76	·67	1·22	·85
February	·72	·67	·94	·85
March	·80	·67	1·03	·86
April	·67	·67	1·02	·86
May	·74	·68	·93	·86
June	·70	·66	·88	·86
July	·84	·66	1·11	·86
August	·79	·66	·85	·86
September	·89	·68	1·06	·86
October	·85	·68	1·10	·86
November	·83	·67	1·17	·85
December	·78	·67	1·10	·85
Year	·82	·68	1·09	·85

(14) The amplitude of the second component is slightly less at stations on the sea coast than at stations in the same latitude in the interior.

The following gives examples :—

	Ratio of values of U_2 for				
	Trichinopoly to Madras.	Mean of Poona, and Nagpur to Bombay.	Calcutta to Chittagong.	Mean of Bellary and Trichinopoly to Aden.	Mean of Patna and Allahabad to Kurrachee.
January	1·08	1·03	1·14	1·25	1·07
February	1·15	1·06	1·07	1·29	1·05
March	1·12	1·13	1·11	1·39	1·16
April	1·07	1·09	1·06	1·29	1·21
May	1·11	1·09	1·13	1·27	1·27
June	1·03	1·02	1·10	1·29	1·42
July	1·06	1·08	1·03	1·17	1·32
August	1·10	1·05	1·13	1·24	1·33
September	1·09	1·02	1·05	1·24	1·34
October	1·11	1·02	1·06	1·28	1·20
November	1·07	0·98	1·06	1·08	1·07
December	1·02	0·98	1·14	1·33	1·02

The preceding data show that the amplitude at coast stations in India is slightly less than at stations in the same latitude in the interior. The differences are small in actual amount and vary very slightly throughout the year.

(15) The variations in the amplitude of the second component are practically the same in relative amount over the whole of India. This may be shown either for groups of stations or for single stations :—

(1) Groups of stations.

Area.	January. a	March. b	June. c	September. d	Ratio. b/a	b/c	d/c
	″	″	″	″			
Extra-Tropical India, Inland	·03722	·03861	·03113	·03535	1·04	1·24	1·14
Tropical India, Inland	·04532	·04767	·03397	·04189	1·05	1·40	1·24

The following table gives corresponding data for eight representative stations in different parts of India :—

(2) Single Stations.

Station.	January. a	March. b	June. c	September. d	Ratio. b/a	b/c	d/c
	″	″	″	″			
Lahore	·02597	·02829	·02340	·02557	1·09	1·21	1·09
Allahabad	·03654	·03995	·03228	·03679	1·09	1·24	1·14
Calcutta	·04214	·04510	·03512	·04152	1·07	1·28	1·18
Kurrachee	·03652	·03514	·02386	·02845	0·96	1·47	1·19
Nagpur	·04248	·04631	·03305	·03911	1·09	1·40	1·18
Trichinopoly	·04803	·05123	·04038	·04843	1·07	1·27	1·20
Bombay	·04290	·04210	·03200	·03770	0·98	1·32	1·18
Madras	·04438	·04571	·03936	·04449	1·03	1·16	1·13

The data show fully that the amplitude of the second component increases or decreases from one period of the year to another by almost exactly the same relative amount over the whole of India. This is a strong confirmation of the inference from the whole of the data that the second component depends mainly upon general and not upon local conditions.

(16) The amplitude of the second component varies very considerably in actual amount in India, ranging on the mean day of the year from ·04686″ at Trichinopoly to ·02450″ at Lahore. It is apparently a function of the latitude and various investigators, more especially Hann and Angot, have utilized the whole of the available data to give expressions for the amplitude in terms of the latitude. Hann's formula will be found in chapter IX of the present memoir.

The following gives a comparison of the amplitudes of the second component for the mean day of the year with the normal values, as given by Hann's formula, for the latitudes in which these stations are situated:—

Area.	Lat. N.	Station.	Actual amplitude on the mean day of the year.	Normal amplitude on the mean day of the year.	Variation from normal.
			″	″	″
Inland Stations	11°	Trichinopoly	·0469	·0358	+·0111
	15°	Bellary	·0421	·0343	+·0078
	16°	Belgaum	·0404	·0386	+·0018
	18°	Poona	·0404	·0327	+·0077
	21°	Nagpur	·0394	·0311	+·0083
	23°	Calcutta	·0401	·0307	+·0094
	23°	Jubbulpore	·0364	·0299	+·0065
	24°	Deesa	·0370	·0295	+·0075
	25°	Allahabad	·0358	·0284	+·0074
	26°	Patna	·0384	·0284	+·0100
	27°	Agra	·0347	·0276	+·0071
	27°	Jaipur	·0331	·0276	+·0051
	30°	Roorkee	·0315	·0256	+·0059
	32°	Lahore	·0245	·0240	+·0005
Coast Stations	9°	Trivandrum	·0429	·0365	+·0064
	13°	Madras	·0433	·0354	+·0079
	13°	Aden	·0354	·0350	+·0004
	17°	Rangoon	·0399	·0335	+·0064
	22°	Chittagong	·0369	·0303	+·0066
	25°	Kurrachee	·0311	·0287	+·0024

The preceding data show that, employing one of the formulæ which fairly represent the general facts of the annual variation of the amplitude of the second component, the amplitudes in India are in all cases larger than those of corresponding latitudes. The differences are large and fairly uniform in amount over the whole area. They are slightly less in amount at the coast than the interior stations, and are locally small at Lahore, Belgaum, Kurrachee and Aden. The comparison is not possible for seasons or months.

17. The amplitude of the second component is probably slightly larger in mountain valleys than at the same level in the open. The chief examples are Leh and Srinagar.

The following gives a summary of the chief features of the second component of the diurnal pressure oscillation in India:—

(1) *The second component has the largest amplitude of all the components of the Besselian resolution of the diurnal pressure oscillation in India. The following gives comparative data of the first and second components for the mean day of the year and also for the dry and wet seasons:—*

Area.	Amplitude of U_1.			Amplitude of U_2.		
	Mean day of year.	Dry seasons.	Wet season.	Mean day of year.	Dry season.	Wet season.
	"	"	"	"	"	"
Extra-Tropical India . . .	·02743	·02813	·02709	·03526	·03691	·03355
Tropical India	·02399	·02696	·02018	·04136	·04394	·03659

(2) *The second component is on account of its magnitude, the most important feature of the diurnal oscillation. The ratio of U_2 to U_1 is larger for Tropical than for Extra-Tropical India, as the first component is smaller for the former than the latter area, and the second component larger.*

(3) *The second component at low level stations is independent to a remarkable extent of local conditions, and is chiefly a function of the latitude. The amplitudes of the second component at all stations in India except Lahore, Belgaum and Kurrachee, and also at Aden, are considerably larger than the normal values at stations in the same latitudes, as deduced by Hann and Angot. This excess is nearly constant in amount, but is slightly smaller at the coast stations, and slightly larger at the interior stations in South India than at the remaining stations.*

(4) *The amplitude of the second component is very slightly less at coast stations than at stations in the interior in the same latitude in India. The differences are very small.*

(5) *The amplitude of the second component decreases with elevation at approximately the same rate as the actual pressure decreases. The rate of decrease is slightly less in the wet than the dry season.*

(6) *Hence in open plains or in the open sea, the amplitude of the second component is practically independent of local conditions and is determined by latitude and by any general conditions prevailing over large areas, as in India.*

(7) *The rate of variation of the amplitude of the second component is nearly uniform over the whole of India from one month to another or from one season to another. The ratio of the absolute maximum to the absolute minimum amplitude at any station is very approximately 4 to 3.*

(8) *The second component has a fairly well defined double variation in the course of the year at the great majority of stations in India, viz., 24 out of 32, for which data have been collected. At the remaining eight stations it has a single oscillation or variation.*

(9) *The absolute maximum is in February or March, and the absolute minimum in June or July.*

(10) *The maximum epochs are earliest at the most southern stations, and are later with increasing latitude. The range of variation differs very little with latitude and averages 40 minutes for the year. The maximum phase is earliest in the day in November, and is retarded from November to July, when it is latest in the day and is accelerated during the remainder of the year. The range of variation during the year in the mean epoch of the maximum phase is only 32 minutes.*

(11) *The absolute minimum occurs in July in Extra-Tropical India Inland and in Tropical India, and in June in mountain peaks and valleys and Extra-Tropical India Coast; hence tending to occur earlier in coast and mountain districts.*

(12) *The secondary maximum is in September in Extra-Tropical India and in October in Tropical India, and the secondary minimum in the following month in both areas. The amplitude of this secondary variation is less than a third of that of the larger or primary variation from March to June.*

(13) *The secondary maximum and minimum, are very feebly marked or are absent at most stations in Extra-Tropical India inland and Tropical India Coast. In the remaining plain districts they occur in consecutive months, i.e., in Extra-Tropical India Coast in September and October and in Tropical India Inland in October and November. It is hence evident they are not, strictly speaking, seasonal or related to the sun's distance.*

(14) *The most important features of the second component are the occurrence of the maximum amplitude of the variation in February or March and the minimum in July, and also the well-marked tendency to occurrence of both in the coast and mountain districts of India a month earlier than in the interior.*

The third and fourth components.—The third and fouth components of the Besselian resolution of the diurnal oscillation of the barometer in India are very small in actual amount as compared with the first and second components. The following gives the values for the mean day of the year of the first four components for Tropical and Extra-Tropical India :—

Area.	Value of amplitude for mean day of year of			
	First component.	Second component.	Third component.	Fourth component.
	"	"	"	"
Tropical India	·02399	·04136	·00147	·00134
Extra-Tropical India . . .	·02743	·03526	·00169	·00104

The mean or annual values of the amplitude of the third and fourth components are less than three thousandths of an inch and less than the mean probable error of a single observation in India.

An important consideration is whether the third and fourth components represent the effects of independent physical realities or actions (as Hann and Cole maintain) or whether they are merely terms in a mathematical expression, giving the same total (or hourly) values as the original data from which they are derived, or, in other words, whether they are simply harmonic components, in which case the third component would be chiefly related to the first, and the fourth to perhaps both the first and second.

These two components undoubtedly present uniformities differing to some extent in character from those of the first and second components, thus suggesting the possibility or probability that they represent independent physical realities.

The epochs and amplitudes of the third component.—The amplitude of the third component in its annual variation has a well defined absolute maximum and minimum. The absolute maximum occurs in December at four stations in Tropical

India, and three stations in Extra-Tropical India, and in January at eleven stations in Tropical and fourteen stations in Extra-Tropical India, as shown below :—

AREA.	Month of absolute or primary maximum.	STATION.	Absolute or primary maximum amplitude.
TROPICAL INDIA	December	Rangoon	″ ·00842
		Nagpur	·00645
		Jubbulpore	·00512
		Cuttack	·00581
	January	Agustia	·00166
		Trivandrum	·00384
		Trichinopoly	·00282
		Madras	·00456
		Bellary	·00546
		Belgaum	·00581
		Poona	·00631
		Bombay	·00660
		Pachmarhi	·00643
		Chittagong	·00764
		Aden	·00550
EXTRA-TROPICAL INDIA.	December	Goalpara	·01049
		Lahore	·00718
		Leh	·00661
	January	Calcutta	·00834
		Sibsagur	·00757
		Dhubri	·00936
		Patna	·00613
		Hazaribagh	·00766
		Allahabad	·00841
		Lucknow	·00781
		Agra	·00700
		Jaipur	·00849
		Deesa	·00660
		Kurrachee	·00759
		Roorkee	·00643
		Lahore	·00718
		Simla	·00616

The maximum values hence range between one thousandth and ten thousandths of an inch. They vary somewhat irregularly from station to station, and are apparently not related to geographical position or local conditions, such as elevation, distance

from the sea or mountain ranges, position in valleys, etc. The maximum values obtain at the great majority of stations in January and at the remaining stations in December, the tendency to occurrence in that month being slightly greater in Tropical than in Extra-Tropical India. The absolute maximum of the third component is hence even more regular in its occurrence over the whole of India, than those of the first and second components, the mean epoch being January (about the middle of the second week of the month so far as can be inferred from the data).

The following gives corresponding data for the epoch of the absolute minimum amplitude of the third component :—

AREA.	Month of absolute minimum.	STATION.	Absolute or primary minimum amplitude.
			°
TROPICAL INDIA	March	Trichinopoly	·00022
		Rangoon	·00124
		Chittagong	·00161
	April	Madras	·00114
		Bellary	·00064
		Bombay	·00080
		Nagpur	·00117
		Pachmarhi	·00166
		Jubbulpore	·00036
	May	Trivandrum	·00058
		Poona	·00042
		Cuttack	·00172
		Aden	·00158
EXTRA-TROPICAL INDIA	March	Patna	·00057
		Jaipur	·00162
		Roorkee	·00214
	April	Calcutta	·00213
		Hazaribagh	·00098
		Goalpara	·00083
		Allahabad	·00163
		Lucknow	·00070
		Agra	·00277
		Deesa	·00104
		Kurrachee	·00120
		Lahore	·00124
	May	Sibsagar	·00120
		Leh	·00144

The absolute minimum is somewhat less regular in its occurrence than the absolute maximum. It occurs during the period March to May and on the mean of all stations in April. There is a slight tendency for it to occur earlier in Extra-Tropical than in Tropical India.

The mean of the absolute minimum values of the amplitude is ·00101″ for Tropical India, and ·00139″ for Extra-Tropical India.

The minimum values of the amplitude of the third component vary irregularly from station to station and are apparently not related to geographical or local conditions.

There are also a fairly well marked secondary maximum and minimum in the annual variation of the monthly values of the amplitude of the third component.

The following gives data showing the epochs and amplitudes of the secondary maximum :—

Area.	Month of secondary maximum amplitude.	Station.	Secondary maximum amplitude.
			″
Tropical India	May	Madras	·00294
		Rangoon	·00247
	June	Bellary	·00289
		Poona	·00252
		Bombay	·00370
		Nagpur	·00366
		Cuttack	·00181
		Chittagong	·00411
		Aden	·00439
	July	Belgaum	·00212
		Jubbulpore	·00199
Extra-Tropical India	May	Calcutta	·00451
		Dhubri	·00430
		Patna	·00452
		Hazaribagh	·00379
		Allahabad	·00485
		Kurrachee	·00347
		Lahore	·00473
	June	Goalpara	·00456
		Lucknow	·00313
		Agra	·00532
		Roorkee	·00480
		Deesa	·00394
		Jaipur	·00469

The mean of the amplitude of the secondary maximum is ·00296″ in Tropical India and ·00435″ in Extra-Tropical India.

The following gives corresponding data for the secondary minimum:—

Area.	Month of secondary minimum amplitude.	Station.	Secondary minimum amplitude.
Tropical India	August	Trivandrum	·00045
		Rangoon	·00036
		Belgaum	·00139
		Poona	·00184
		Jubbulpore	·00103
	September	Madras	·00022
		Trichinopoly	·00081
		Bellary	·00136
		Nagpur	·00199
		Cuttack	·00128
		Pachmarhi	·00235
		Aden	·00036
Extra-Tropical India	August	Calcutta	·00131
		Dhubri	·00175
		Lucknow	·00108
		Deesa	·00082
		Lahore	·00180
	September	Patna	·00143
		Hazaribagh	·00150
		Allahabad	·00181
		Agra	·00197
		Jaipur	·00130
		Kurrachee	·00133
		Roorkee	·00133
		Srinagar	·00180
		Simla	·00108

The mean value of the amplitude of the secondary minimum is ·00112″ for Tropical India and ·00145″ fot Extra-Tropical India.

A noteworthy feature is that the critical epochs of the first and third components occur in the same months, and that the maximum *epochs of one correspond* with the

minimum of the other, and *vice versâ*. There is no similar correspondence between the epochs of the second and third components. The following gives data in illustration:—

Phase.	Epoch for		
	First component.	Third component.	Second component.
Absolute Maximum	April	January	February or March.
Ditto. Minimum	July	April	June or July.
Secondary Maximum	September	May or June	September or October.
Ditto. Minimum	January	September	October or November.

The following is a tabular summary of the chief results relating to the epochs and amplitudes of the maximum and minimum phases of the third component:—

Phase.	Period of phase.	Mean amplitude, Tropical India.	Mean amplitude, Extra-Tropical India.
Absolute or primary maximum.	January	·00541	·00778
Absolute or primary minimum.	April	·00154	·00172
Secondary maximum	May or June	·00247	·00370
Secondary minimum	September	·00146	·00177

The maximum values are at the Solstices and the minimum values at the Equinoxes approximately. The extreme or critical values are all slightly larger in Extra-Tropical than in Tropical India, and there is a very slight tendency for the minimum critical phases to occur earlier in the former than the latter area.

The following is a summary of the data given in table CXVI, page 310, at the conclusion of this chapter:—

Area.	Mean amplitude of the third component.											
	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.
	"	"	"	"	"	"	"	"	"	"	"	"
Extra-Tropical India, Inland	·00747	·00494	·00246	00162	·00352	·00365	·00318	·00208	·00183	·00350	·00570	·00697
Extra Tropical India, Coast	·00786	·00512	·00307	00208	·00386	·00311	·00301	·00193	·00171	·00344	·00605	·00722
Tropical India, Inland	·00530	00334	·00161	·00148	·00171	·00227	·00209	00186	·00204	·00353	·00405	·0048[illegible]
Tropical India, Coast	·00510	·00407	·00199	·00128	·00174	·00230	·00198	·00114	·00076	·00234	·00417	·00468
Mountain Peak	·00391	·00065	·00160	·00099	·00190	·00161	·00186	·00145	·00103	·00204	·00303	·00324
Mountain Valley	·00483	00423	·00342	·00245	·00235	00318	·00283	·00229	·00271	·00409	·00540	·00608

The preceding data indicate the large variability in the mean monthly values of the amplitudes. The ratio of the absolute maximum and minimum values is very approximately 4 to 1 for plains stations. The corresponding ratio for the first and second

components is approximately 4 to 3. Hence the third component is three times as variable as the first and second components. The variability is on the whole greater for stations in Extra-Tropical than in Tropical India. It is also less variable in mountain valleys than at the neighbouring plains stations, and more variable at stations on mountain ridges.

The epochs of the maximum and minimum amplitudes of the third component are also considerably modified in mountain valleys. The maxima values at Leh and Srinagar are in the winter months and the minima values in July and September.

In Extra-Tropical India, the amplitude of the third component is greater at the coast stations than the interior stations from November to May and less during the remainder of the year. These two periods practically coincide with the wet and dry seasons. In Tropical India the amplitude of the third component is generally smaller at the coast stations than the interior stations.

The epochs of the maximum and minimum phases of the third component vary very largely during the year.

The following gives the mean epochs of the first maximum for each month of the year in the six groups of stations adopted in the preceding table :—

Area.	Mean Epoch of the third component.																							
	January.		February.		March.		April.		May.		June.		July.		August.		September.		October.		November.		December.	
	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.
Extra-Tropical India, Inland .	2	12	2	20	2	22	5	5	5	49	5	44	5	43	5	17	3	23	1	55	1	59	2	9
Extra-Tropical India, Coast .	2	4	1	57	1	24	6	33	6	12	6	9	6	4	5	54	2	41	1	55	1	51	2	0
Tropical India, Inland . .	2	10	2	29	2	48	5	9	6	6	6	1	6	9	5	10	3	1	2	20	1	58	2	3
Tropical India, Coast . .	1	58	1	56	1	53	4	36	5	19	6	3	5	35	5	3	2	27	1	36	1	41	1	42
Mountain Peak Stations . .	1	54	1	37	3	58	4	21	5	20	5	39	5	42	5	25	4	21	2	26	1	53	1	58
Mountain Valley Stations .	1	58	2	22	2	13	4	28	4	21	2	16	4	38	2	45	2	44	2	5	2	5	2	13

The preceding data indicate the very great variability in the epoch of the critical phases of the third component, the period of which is only eight hours. Thus in Tropical India, the first maximum phase of the day ranges between 1-58 A.M. and 6-9 A.M., an interval of 4 hours 11 minutes. The most remarkable feature is the sudden retardation of two to three hours which takes place from March to April, and a similar acceleration from August to September. This feature is unique.

The following gives a summary of the more important features of the third component of the Besselian resolution of the diurnal pressure oscillation in India.

(1) *The amplitude of the third component is very small compared with those of the first and second components. The average value for the mean day of the year in Tropical India is ·0021″, and in Extra-Tropical India is ·0015″, and is hence larger in the former than in the latter area.*

(2) *The monthly values of the amplitudes have a well defined double variation giving a primary or absolute maximum and minimum and secondary maximum and minimum.*

(3) *The absolute maximum occurs at the great majority of stations in both Tropical and Extra-Tropical India in January and at the remaining stations in December. The maximum*

values range between ·002" at Agustia and ·010" at Goalpara, and average ·0055" in Tropical India and ·0076" in Extra-Tropical India.

(4) *The absolute minima values occur during the period March to May and at the majority of stations in April. The mean value of the minimum amplitude is ·00101" for Tropical India and ·00139" for Extra-Tropical India.*

(5) *The secondary maximum occurs at the great majority of stations in May or June, on the average of all stations in Tropical India in the third week of June and in Extra-Tropical India at the end of May or beginning of June. The values average ·00296" for Tropical India and ·00435" for Extra-Tropical India.*

(6) *The secondary minimum occurs in August at ten stations and in September at sixteen stations and on the average of all stations at about the end of the first week of September. The amplitudes average ·00112" for Tropical India and ·00145" for Extra-Tropical India.*

(7) *The most remarkable feature of the third component is that the epochs of the maximum and minimum values of the amplitude agree very closely with those of the first component, and that the maximum epochs of the one correspond with the minimum epochs of the other.*

(8) *A second remarkable feature is the large change of epoch of the maximum phases in the diurnal variation at the solstices, that is from March to April and from September to October when the epochs change suddenly by about two hours.*

The epochs and amplitudes of the fourth component.—The fourth component is even more variable and irregular than the third. In Tables CXVII and CXXI are given data of the monthly values of the epoch and amplitude at 32 stations The chief feature of the monthly values of the amplitude is the occurrence of a well marked primary maximum and minimum. The primary maximum occurs on the mean of all stations in January and the primary minimum in June and July. Secondary maxima and minima also occur, but in so irregular a manner that it is not possible to deduce any general law as to their occurrence.

The following gives data showing the epochs and values of the absolute maximum amplitudes :—

Area	Month of absolute maximum amplitude.	Station.	Absolute or primary maximum amplitude.
Tropical India	December	Bellary	·00225
		Rangoon	·00234
		Nagpur	·00228
		Jubbulpore	·00269
		Cuttack	·00236
		Chittagong	·00328
	January	Poona	·00256
		Bombay	·00340
		Pachmarhi	·00243
	February	Trichinopoly	·00206
		Madras	·00240
		Trivandrum	·00221
		Mean	·00252

AREA.	Month of absolute minimum amplitude.	STATION.	Absolute of primary maximum amplitude.
			°
EXTRA-TROPICAL INDIA.	December	Sibsagar	·00276
		Dhubri	·00276
		Goalpara	·00348
		Hazaribagh	·00312
		Allahabad	·00332
		Leh	·00278
	January	Calcutta	·00314
		Patna	·00365
		Lucknow	·00276
		Agra	·00338
		Deesa	·00322
		Jaipur	·00319
		Kurrachee	·00284
		Roorkee	·00394
		Lahore	·00298
		Srinagar	·00549
		Simla	·00301
		Mean	·00328

The data indicate that the epoch of the absolute maximum is slightly earlier in Tropical than in Extra-Tropical India, occurring at the majority of stations in the former area in December and in the latter area in January. The maximum amplitudes are larger in the latter than the former area, averaging ·00328″ in Extra-Tropical India and ·00252″ in Tropical India. A noteworthy feature is the very slight variation in the maximum amplitude in each of the two areas.

The absolute minimum is much less regular in its occurrence than the absolute maximum. The following gives data :—

AREA.	Month of absolute minimum amplitude.	STATION.	Absolute minimum amplitude.
			″
TROPICAL INDIA	March	Bellary	·0003
		Jubbulpore	·00067
	April	Bombay	·00040
	June	Belgaum	·00067
		Trichinopoly	·00086
		Madras	·00063
		Poona	·00050

AREA.	Month of absolute maximum amplitude.	STATION.	Absolute minimum amplitude.
			"
TROPICAL INDIA—*contd.*	July	Trivandrum	·00032
		Augustia	·00051
		Pachmarhi	·00020
	September . .	Nagpur	·00036
		Chittagong	·00022
		Cuttack	·00022
	February . .	Sibsagar	·00145
		Goalpara	·00102
EXTRA-TROPICAL INDIA	March . .	Dhubri	·00058
		Kurrachee	·00010
		Jaipur	·00030
		Srinagar	·00148
		Leh	·00058
	April . . .	Deesa	·00036
		Lahore	·00078
		Lucknow	·00022
	May . . .	Allahabad	·00030
		Agra	·00100
	June . . .	Calcutta	·00051
		Patna	·00008
		Hazaribagh	·00059
		Goalpara	·00139
		Simla	·00022
	July . . .	Roorkee	·00051

The values of the absolute minimum are so small (in all but five cases less than a thousandth of an inch) that it is undesirable to place much reliance upon them. For, as already stated, it is very doubtful whether results based on hourly observations for 40 to 50 days in each month are sufficient to eliminate all irregularities and give accurate results by the application of the Besselian methods of resolution.

The utmost that can be said is that there appears to be a marked tendency to the occurrence of the absolute minimum amplitude of the fourth component in June or July. Its value is very small, averaging ·00045" in Tropical India and ·00064" in Extra-Tropical India.

The amplitude does not appear to depend directly upon geographical position, elevation or position with respect to the sea or mountain ridges and varies irregularly from station to station.

The following table gives a summary of the mean monthly values of the amplitude of the fourth component in six groups of stations, derived from the data of table CXVII :—

Area.	Mean amplitude of the fourth component.											
	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.
	"	"	"	"	"	"	"	"	"	"	"	"
Extra-Tropical India, Inland .	·00300	·00132	·00095	·00098	·00137	·00110	·00112	·00106	·00115	·00149	·00194	·00301
Extra-Tropical India, Coast .	·00273	·00114	·00065	·00087	·00104	·00072	·00075	·00159	·00087	·00169	·00178	·00303
Tropical India, Inland . .	·00184	·00171	·00091	·00103	·00095	·00073	·00070	·00089	·00130	·00109	·00177	·00204
Tropical India, Coast . .	·00215	·00216	·00160	·00112	·00071	·00081	·00054	·00102	·00108	·00174	·00149	·00184
Mountain Peak . . .	·00172	·00105	·00086	·00076	·00074	·00072	·00064	·00098	·00121	·00099	·00105	·00187
Mountain Valley . . .	·00342	·00195	·00116	·00124	·00117	·00131	·00105	·00124	·00099	·00138	·00171	·00247

The following table gives monthly data of the epochs of the first maximum phase of the fourth component in its diurnal variation for the six groups of stations :—

Area.	Mean epoch of the fourth component.											
	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.
	H. M.	H. M.	H. M.	H. M.	H. M.	H. M.	H. M.	H. M.	H. M.	H. M.	H. M.	H. M.
Extra-Tropical India, Inland .	3 41	4 4	3 13	2 34	2 33	2 28	2 2	2 32	2 36	3 31	3 39	3 47
Extra-Tropical India, Coast .	3 58	3 52	3 13	2 21	3 0	2 8	2 45	3 43	3 54	3 44	3 38	3 49
Tropical India, Inland . .	2 10	2 29	2 48	5 9	6 6	6 1	6 9	5 10	3 1	2 20	1 58	2 3
Tropical India, Coast . .	3 40	3 54	3 34	3 3	2 12	2 5	1 58	3 36	3 30	3 28	3 24	2 27
Mountain Peak . . .	4 14	4 27	4 24	3 15	2 49	2 47	2 26	4 9	3 53	3 45	3 34	4 0
Mountain Valley . .	4 19	4 56	4 6	4 47	1 8	2 40	1 40	2 38	1 23	2 38	4 20	4 23

The preceding data show the large variability in the epoch of the fourth component, the period of which is only six hours. The epochs are generally earliest in June or July and latest in January or February, the range of variation averaging two hours.

The following gives a summary of the more important features of the fourth componen —

(1) *The amplitude of the fourth component is small in India, averaging ·00134" in Tropical India and ·00104" in Extra-Tropical India.*

(2) *Its variability is very large, twice as large as that of the third component, and six times as large as that of either the first or second component.*

(3) *The monthly values of the amplitude of the fourth component have a well marked primary maximum and minimum.*

(4) *The primary maximum is in December in Tropical India and in January in Extra-Tropical India. The maximum values are slightly larger in Extra-Tropical than in Tropical India, averaging ·00328" in the former area and ·00252" in the latter area.*

5. *The minimum values are more irregular in their occurrence than the maximum. They are at the great majority of stations in both Extra-Tropical and Tropical India in June or July. The epoch of the maximum and minimum values hence agree approximately with the periods of greatest and least distance of the sun from the earth. The minimum values average ·00045" in Tropical*

India and ·0006.4″ in Extra-Tropical India, and are hence slightly larger in the latter than the former area.

6. The mean maximum and minimum values are not proportional to the square of the sun's distance at perigee and apogee.

7. The variations in the amplitudes from month to month or from station to station do not appear to depend upon geographical position or local conditions.

8. There is a tendency to the occurrence of secondary minima and maxima values at the majority of stations, the former in March and September and the latter in May and August.

9. The amplitudes of the fourth component vary on the whole in a similar manner to those of the second component.

TABLE CXIV.—*Showing the amplitudes of U_1 of air pressure.*

Latitude North.	Elevation in feet.	STATION.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Year.
° ′			″	″	″	″	″	″	″	″	″	″	″	″	″
8 31	195	Trivandrum .	·01962	·02108	·02093	·01698	·01457	·01018	·01175	·01528	·01782	·01677	·01449	·01508	·01608
8 37	6,200	Agustia .	·00588	·01072	00777	·00555	·00570	·00599	·00587	·00683	·00272	·00593	·00274	·00361	·00523
10 50	255	Trichinopoly .	·02390	·03274	·03785	·03500	·03096	·02887	·02692	·03413	·03503	·02643	·01906	·01543	·02859
12 45	94	Aden .	·02076	·02604	·03232	·02732	·03073	·04309	·04781	·04851	·03306	·02183	·02238	·02014	·03013
13 4	22	Madras .	·01658	·02010	·02472	·02956	·02617	·03066	·03074	·03029	·03050	·02218	·01365	·01240	·02378
15 9	1,475	Bellary .	·03329	·03782	·03941	·04031	·04349	·02853	·02248	·02994	·03413	·03130	·02851	·02899	·03254
15 52	2,524	Belgaum .	·02277	·02216	·02619	·02634	·02586	·01189	·00545	·00762	·01468	·02022	·01940	·01692	·01804
16 46	41	Rangoon .	·02789	·03232	·03904	·04481	·02619	·01449	·01750	·01692	·02331	·03125	·02406	·02720	·02666
18 28	1,840	Poona .	·03026	·03241	·03542	·03239	·02850	·01672	·00496	·01016	·01668	·02705	·03404	·02865	·02455
18 54	37	Bombay .	·02040	·02300	·02600	·02800	·02420	·01170	·00810	·00950	·01350	·02010	·02130	·02010	·01840
20 29	80	Cuttack .	·02977	·03237	·03738	·03678	·03553	·02304	·02254	·01754	·02103	·02380	·02645	·02990	·02799
21 9	1,025	Nagpur .	·02767	·03373	·04013	·04519	·04241	·02860	·02092	·02068	·02312	·02583	·02689	·02676	·02987
22 21	87	Chittagong .	·02009	·02554	·02855	·02847	·02765	·01743	·01701	·02195	·02422	·02749	·02330	·02298	·02262
22 28	3,528	Pachmarhi .	·01019	·01456	·01841	·02207	·02511	·01847	·01294	·01329	·01228	·01265	·01168	·00966	·01478
22 32	21	Calcutta .	·02596	·03150	·03305	·03482	·02862	·02283	·02077	·02046	·02072	·02402	·02509	·02720	·02595
23 9	1,327	Jubbulpore .	·02452	·02551	·03226	·03616	·03803	·03740	·02087	·02101	·02382	·02380	·02514	·02648	·02701
24 0	2,007	Hazaribagh .	·01704	·01950	·02469	·02873	·02606	·02040	·01500	·01865	·02222	·01978	·01857	·01693	·02032
24 16	466	Deesa .	·02179	·02304	·03405	·03694	·04130	·03810	·02357	·02357	·02940	·02724	·02286	·02293	·02872
24 47	49	Kurrachee .	·02222	·02278	·02126	·02107	·02128	·01720	·01447	·01527	·01991	·02071	·02036	·02327	·01937
25 26	309	Allahabad .	·02485	·02918	·03715	·03977	·04053	·03512	·02360	·02491	·03046	·02745	·02585	·02578	·03020
25 37	183	Patna .	·02554	·02955	·03625	·04055	.04191	·03089	·02563	·02694	·03024	·02955	·02750	·02845	·03084
26 7	115	Dhubri .	·03192	·03348	·04317	·04546	·04545	·03386	·03219	·03346	·02931	·03587	·03140	·03223	·03532
26 11	386	Goalpara .	·02830	·03344	·04058	.04594	·04439	·02928	·02508	·03099	·03438	·03297	·03243	·03408	·03407
26 50	370	Lucknow .	·02138	·02221	·02927	·03224	·03818	·03438	·02395	·02418	·02530	·02518	·02298	·02139	·02617
26 55	1,431	Jaipur .	·01732	·02228	·02722	·03204	·03569	·03468	·02411	·02329	·02510	·02491	·01999	·02001	·02498
26 59	333	Sibsagar .	·03095	·03065	·03110	·03422	·03274	·02970	·03365	·03758	·03529	·03417	·03502	·03585	·03328
27 10	555	Agra .	·02101	·02539	·02967	·03688	·03555	·03256	·02786	·02895	·02747	·02498	·02385	·02416	·02807
29 52	887	Roorkee .	·01501	·01365	·02217	·03173	·03366	·03990	·03120	·03090	·03314	·02569	·02090	·01928	·02602
31 6	7,070	Simla .	·00731	·00923	·00959	·01212	·01705	·01324	·00943	·00728	·01288	·00941	·00955	·00960	·01004
31 34	702	Lahore .	·01443	·01754	·02192	·02620	·03149	·03980	·03322	·03405	·03067	.02842	·01822	.01906	·02501
34 10	11,503	Leh .	·01900	·02073	·03081	·03155	·03040	·03758	·04581	·04328	·04665	·04057	·03408	·02752	·03374
34 4	5,204	Srinagar .	·00621	·01174	·01637	·01182	·02170	·02489	·02953	·03172	·03217	·03540	·02607	·01806	·02117

TABLE CXV.—*Showing the amplitudes of U_2 of air pressure.*

[illegible]	[illegible]	[illegible]	Station.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Year.
				"	"	"	"	"	"	"	"	"	"	"	"	"
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
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[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

TABLE CXVI.—*Showing the amplitudes of U_3 of air pressure.*

Latitude.	Elevation in feet.	Station.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Year.
° ′			″	″	″	″	″	″	″	″	″	″	″	″	″
8 31	195	Trivandrum	·00384	·00314	·00193	·00112	·00058	·00099	·00097	·00045	·00085	·00196	·00303	·00337	·00138
8 37	6,200	Agustia	·00166	·00129	·00109	·00135	·00163	·00089	·00119	·00090	·00077	·00099	·00152	·00112	·00038
10 50	255	Trichinopoly	·00282	·00054	·00022	·00203	·00191	·00160	·00175	·00170	·00081	·00292	·00242	·00240	·00072
12 45	94	Aden	·00550	·00370	·00407	·00200	·00158	·00439	·00383	·00363	·00036	·00286	·00391	·00385	·00163
13 4	22	Madras	·00456	·00382	·00136	·00114	·00294	·00269	·00241	·00157	·00022	·00158	·00340	·00342	·00085
15 9	1,475	Bellary	·00546	·00386	·00236	·00064	·00121	·00289	·00130	·00197	·00136	·00322	·00432	·00530	·00136
15 52	2,524	Belgaum	·00581	·00394	·00285	·00267	·00132	·00130	·00212	·00139	·00262	·00422	·00393	·00470	·00212
16 46	41	Rangoon	·00732	·00473	·00124	·00143	·00247	·00242	·00221	·00036	·00058	·00402	·00733	·00842	·00231
18 28	1,840	Poona	·00631	·00351	·00133	·00092	·00042	·00252	·00243	·00184	·00344	·00402	·00391	·00546	·00180
18 54	37	Bombay	·00660	·00500	·00240	·00080	·00170	·00370	·00280	·00130	·00070	·00320	·00490	·00610	·00170
20 29	80	Cuttack	·00538	·00431	·00228	·00206	·00172	·00181	·00172	·00133	·00128	·00262	·00535	·00591	·00184
21 9	1,025	Nagpur	·00608	·00483	·00128	·00117	·00369	·00366	·00285	·00242	·00190	·00339	·00561	·00645	·00158
22 21	87	Chittagong	·00764	·00181	·00161	·00291	·00361	·00411	·00336	·00179	·00150	·00332	·00575	·00625	·00143
22 28	3,528	Pachmarhi	·00643	·00462	·00222	·00166	·00311	·00251	·00264	·00166	·00235	·00296	·00466	·00640	·00212
22 32	21	Calcutta	·00834	·00587	·00268	·00213	·00451	·00255	·00267	·00131	·00189	·00362	·00658	·00817	·00189
23 9	1,327	Jubbulpore	·00420	·00265	·00182	·00036	·00189	·00184	·00199	·00103	·00216	·00170	·00374	·00512	·00131
24 0	2,007	Hazaribagh	·00766	·00569	·00162	·00098	·00370	·00205	·00304	·00234	·00150	·00393	·00640	·00702	·00175
24 16	466	Deesa	·00660	·00444	·00385	·00104	·00282	·00394	·00238	·00082	·00133	·00367	·00370	·00564	·00136
24 47	49	Kurrachee	·00759	·00469	·00491	·00120	·00347	·00267	·00209	·00270	·00133	·00337	·00581	·00723	·00202
25 26	309	Allahabad	·00841	·00581	·00328	·00163	·00485	·00361	·00359	·00350	·00181	·00395	·00714	·00819	00173
25 37	183	Patna	·00513	·00459	·00057	·00263	·00452	·00449	·00359	·00242	·00143	·00280	·00372	·00574	·00045
26 7	115	Dhubri	·00936	·00586	·00182	·00215	·00430	·00356	·00389	·00175	·00150	·00395	·00580	·00849	·00170
26 11	386	Goalpara	·01032	·00613	·00264	·00083	·00424	·00456	·00328	·00133	·00105	·00464	·00855	·01049	·00251
26 50	370	Lucknow	·00781	·00503	·00250	·00070	·00273	·00313	·00243	·00108	·00170	·00187	·00571	·00635	·00193
26 55	1,431	Jaipur	·00849	·00506	·00162	·00179	·00161	·00169	·00332	·00179	·00130	·00360	·00683	·00721	·00179
26 59	333	Sibsagar	·00757	·00646	·00388	·00275	·00120	·00155	·00250	·00339	·00414	·00468	·00611	·00630	·00356
27 10	555	Agra	·00700	·00447	·00285	·00277	·00486	·00532	·00408	·00203	·00197	·00337	·00521	·00653	·00073
29 52	887	Roorkee	·00643	·00324	·00214	·00221	·00416	·00480	·00380	·00286	·00133	·00337	·00590	·00641	·00094
31 6	7,070	Simla	·00616	0	·00211	·00063	·00216	·00232	·00252	·00200	·00108	·00308	·00453	·00536	·00151
31 34	702	Lahore	·00718	·00476	·00342	·00124	·00473	·00358	·00340	·00180	·00214	·00391	·00532	·00718	·00170
34 10	11,503	Leh	·00654	·00423	·00480	·00282	·00144	·00222	·00094	·00177	·00399	·00398	·00629	·00661	·00330
32 4	5,204	Srinagar	00153	·00383	·00323	·00286	·00251	·00180	·00491	·00244	·00180	·00532	·00526	·00523	·00237

TABLE CXVII.—*Showing the amplitudes of U_4 of air pressure.*

Latitude North.	Elevation in feet.	STATION.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Year.
° ′			″	″	″	″	″	″	″	″	″	″	″	″	″
8 31	195	Trivandrum .	·00128	·00221	·00195	·00123	·00035	·00048	·00032	·00109	·00163	·00172	·00088	·00046	·00108
8 37	6200	Agustia .	·00042	·00116	·00139	·00093	·00062	·00121	·00051	·00153	·00205	·00078	·00063	·00082	·00095
10 50	255	Trichinopoly .	·00149	·00206	·00155	·00182	·00182	·00086	·00103	·00071	·00230	·00130	·00175	·00186	·00139
12 45	94	Aden .	·00166	·00100	·00320	·00177	·00212	·00168	·00331	·00113	·00085	·00230	·00240	·00050	·00110
13 4	22	Madras .	·00184	·00240	·00191	·00130	·00067	·00063	·00072	·00126	·00159	·00184	·00213	·00153	·00136
15 9	1,473	Bellary .	·00140	·00159	·00020	·00080	·00070	·00050	·00036	·00050	·00114	·00076	·00078	·00225	·00040
15 52	2,524	Belgaum .	·00150	·00144	·00127	·00128	·00139	·00067	·00070	·00155	·00212	·00130	·00228	·00166	·00113
16 46	41	Rangoon .	·00015	·00079	·00068	·00102	·00233	·00340	·00234	·00171	·00143	·00067	·00134	·00234	·00114
18 31	1,849	Poona .	·00126	·00242	·00059	·00055	·00036	·00050	·00051	·00085	·00053	·00104	·00206	·00216	·00085
18 54	37	Bombay .	·00210	·00230	·00121	·00040	·00040	·00060	·00060	·00070	·00080	·00170	·00220	·00300	·00120
20 27	80	Cuttack .	·00076	·00172	·00124	·00156	·00140	·00152	·00051	·00103	·00020	·00170	·00076	·00236	·0007[illegible]
21 9	1,025	Nagpur .	·00227	·00116	·00030	·00067	·00050	·00113	·00093	·00081	·00036	·00106	·00200	·00228	·00089
22 21	87	Chittagong .	·00231	·00197	·00135	·00114	·00143	·00114	·00076	·00082	·00022	·00189	·00184	·00328	·00114
22 28	3,503	Pachmarhi .	·00143	·00173	·00143	·00050	·00058	·00076	·00020	·00034	·00042	·00113	·00177	·00172	·00082
22 33	21	Calcutta .	·00214	·00120	·00031	·00122	·00120	·00051	·00067	·00260	·00197	·00204	·00250	·00312	·00140
23 9	1,327	Jubbulpore .	·00023	·00110	·00067	·00133	·00182	·00104	·00152	·00114	·00124	·00132	·00222	·00269	·00071
23 59	2,007	Hazaribagh .	[illegible]	·00117	·00069	·00124	·00157	·00059	·00072	·00144	·00037	·00176	·00283	·00312	·00137
24 15	466	Deesa .	·00222	·00126	·00100	·00036	·00126	·00184	·00173	·00155	·00124	·00225	·00216	·00311	·00125
24 47	22	Kurrachee .	·00174	·00022	·00010	·00031	·00050	·00030	·00051	·00136	·00142	·00114	·00120	·00267	·00067
25 26	307	Allahabad .	·00315	·00114	·00090	·00147	·00030	·00150	·00085	·00032	·00104	·00139	·00199	·00332	·00076
25 37	183	Patna .	·00085	·00132	·00115	·00020	·00068	·00093	·00063	·00079	·00096	·00112	·00131	·00296	·00076
26 2	113	Dhubri .	·00225	·00144	·00038	·00091	·00250	·00108	·00050	·00064	·00220	·00161	·00120	·00276	·00128
26 11	376	Goalpara .	·00319	·00102	·00189	·00089	·00171	·00133	·00211	·00150	·00109	·00240	·00249	·00348	·00146
26 52	370	Lucknow .	·00376	·00067	·00032	·00022	·00137	·00030	·00148	·00054	·00076	·00010	·00100	·00252	·00032
26 55	1,431	Jaipur .	·00319	·00092	·00030	·00032	·00177	·00089	·00085	·00085	·00036	·00095	·00191	·00183	·00035
26 59	332	Sibsagar .	·00220	·00145	·00175	·00248	·00206	·00167	·00127	·00138	·00195	·00213	·00120	·00276	·00172
27 10	555	Agra .	·00338	·00157	·00102	·00120	·00100	·00163	·00104	·00104	·00110	·00314	·00155	·00322	·00145
29 52	887	Roorkee .	·00324	·00222	·00071	·00076	·00136	·00085	·00031	·00172	·00172	·00141	·00274	·00340	·00120
31 6	7,073	Simla .	·00131	·00091	·00032	·00018	·00085	·00022	·00076	·00042	·00036	·00130	·00146	·00291	·00076
31 34	732	Lahore .	·00078	·00133	·00113	·00078	·00101	·00112	·00150	·00178	·00076	·00089	·00153	·00231	·00054
34 10	11,503	Leh .	·00222	·00073	·00098	·00082	·00110	·00101	·00094	·00197	·00114	·00183	·00144	·00278	·00072
34 4	5,204	Srinagar .	·00317	·00127	·00148	·00240	·00184	·00214	·00201	·00150	·00142	·00113	·00191	·00201	·00115

TABLE CXVIII.—*Showing the epochs of the first component* (U_1) *of air pressure.*

Latitude North.	Elevation in feet.	STATION.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Year.
° ′			H. M.	H. M.	H. M	H. M.	H. M.	H. M.	H. M.	H. M.	H. M.	H. M.	H. M.	H. M.	H. M.
8 31	195	Trivandrum	4 59	5 14	5 3	4 58	5 12	4 32	3 51	3 53	4 14	4 9	3 53	4 34	4 36
37	6,200	Agustia .	12 28	13 16	11 55	9 25	7 11	8 44	8 34	7 17	7 44	7 55	12 9	13 47	9 55
10 50	255	Trichinopoly	5 50	5 58	5 56	5 35	5 2	4 49	4 46	4 45	4 41	4 56	4 56	5 30	5 14
12 45	94	Aden .	7 40	7 44	8 15	8 18	7 13	8 8	7 28	7 39	7 53	5 42	4 59	5 46	7 26
13 4	22	Madras .	7 8	7 12	6 50	6 9	5 40	5 41	5 32	5 37	5 18	5 24	6 7	5 58	5 58
15 9	1,475	Bellary .	6 56	7 29	7 12	7 11	7 4	5 37	5 12	5 37	5 32	6 6	6 21	6 18	6 30
15 52	2,524	Belgaum .	6 40	7 15	7 0	6 42	6 25	5 2	6 30	6 18	5 37	6 1	6 0	6 16	6 27
16 46	41	Rangoon .	6 15	7 3	6 55	6 34	6 40	5 44	6 6	5 48	6 8	5 56	5 33	5 52	6 20
18 28	1,840	Poona .	6 14	6 21	6 21	6 9	5 40	4 43	8 17	6 27	5 12	5 35	6 13	6 2	6 4
18 54	37	Bombay .	7 50	7 48	7 43	7 40	8 1	8 42	10 44	9 53	8 12	7 13	7 28	7 34	7 56
20 29	80	Cuttack .	6 14	6 11	6 12	6 17	5 46	5 2	5 1	5 43	5 39	6 0	6 7	6 6	5 54
21 9	1,025	Nagpur .	7 38	7 50	7 34	7 22	7 3	6 21	7 4	6 31	6 8	6 36	6 59	7 8	7 4
22 21	87	Chittagong	6 51	7 27	8 15	8 47	7 41	6 44	5 23	5 54	5 38	6 38	6 0	5 31	6 50
22 28	3,528	Pachmarhi.	8 50	9 31	8 49	8 53	8 8	7 22	7 57	8 37	7 32	8 37	8 50	8 40	8 28
22 32	21	Calcutta .	7 37	7 44	7 35	7 21	7 4	5 58	5 41	5 57	6 21	7 5	6 42	6 52	6 56
23 9	1,327	Jubbulpore	7 38	7 40	7 41	7 32	7 23	6 28	7 2	7 27	6 21	6 51	7 0	7 0	7 12
24 0	2,007	Hazaribagh	8 3	8 25	8 10	7 57	7 52	6 46	6 42	6 39	6 39	7 57	8 2	7 53	7 36
24 16	466	Deesa .	7 53	7 42	7 39	7 50	7 25	6 48	7 39	7 39	7 6	7 9	6 33	7 9	7 20
24 47	49	Kurrachee .	7 22	8 2	8 4	7 40	8 7	6 15	5 36	5 40	6 32	6 46	6 55	6 46	7 5
25 26	309	Allahabad .	8 13	8 25	7 55	8 6	7 35	7 8	6 42	7 2	6 52	7 46	8 0	7 53	7 38
25 37	183	Patna .	7 13	7 29	7 21	7 17	7 22	6 24	6 22	6 35	6 30	7 15	7 12	6 56	7 2
26 7	115	Dhubri .	6 46	7 15	7 2	7 19	7 31	6 33	5 41	5 41	6 15	6 40	6 18	5 58	6 38
26 11	386	Goalpara .	6 37	6 48	7 13	7 47	7 55	6 58	6 18	6 16	6 12	7 3	6 49	6 39	6 57
26 50	370	Lucknow .	8 31	8 34	8 10	8 23	8 4	7 26	6 18	7 5	6 58	7 51	8 6	8 9	7 48
26 55	1,431	Jaipur .	7 55	8 56	8 27	8 14	7 56	7 16	7 32	7 22	7 37	7 46	8 0	8 22	7 55
26 59	333	Sibsagar .	6 39	6 59	7 10	7 42	7 27	6 45	6 58	7 16	6 42	6 44	6 36	6 1	6 55
27 10	555	Agra .	8 52	8 35	8 23	8 30	8 6	8 16	7 48	7 42	7 55	7 57	8 24	8 11	8 11
29 52	887	Roorkee .	8 35	8 56	8 46	8 44	8 39	7 51	7 56	7 58	7 52	8 25	8 30	8 34	8 19
31 6	7,070	Simla .	12 20	12 46	14 2	12 24	11 21	11 2	8 46	9 27	11 9	12 20	11 11	12 24	11 40
31 34	702	Lahore .	8 20	9 36	8 28	8 22	8 32	8 30	8 7	8 32	8 34	8 38	8 4	8 28	8 32
34 10	11,503	Leh .	7 18	6 40	6 59	6 29	5 41	6 36	6 30	6 10	6 40	6 32	6 33	7 6	6 33
34 4	5,204	Srinagar .	12 11	9 3	8 10	9 27	6 38	6 10	7 32	7 4	6 56	6 49	7 15	8 13	7 23

TABLE CXIX.—*Showing the epochs of the second component (U_2) of the air pressure.*

Latitude North.	Elevation in feet.	STATION.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Year.
° ′			H. M.	H. M.	H. M.	H. M.	H. M.	H. M.	H. M.	H. M.	H. M.	H. M.	H. M.	H. M.	H. M.
8 31	193	Trivandrum	9 30	9 38	9 34	9 36	9 37	9 42	9 47	9 41	9 29	9 16	9 14	9 22	9 32
8 37	6,200	Agustia .	9 42	10 0	9 59	9 49	9 41	9 44	10 4	10 0	9 49	9 34	9 26	9 30	9 46
10 50	255	Trichinopoly	9 50	9 59	9 59	9 58	9 52	9 52	9 53	9 53	9 48	9 38	9 39	9 47	9 51
12 45	94	Aden .	9 34	9 44	9 56	9 59	9 46	9 42	9 56	9 39	9 37	9 26	9 23	9 33	9 40
13 4	22	Madras .	9 45	9 52	9 50	9 49	9 48	9 53	9 57	9 53	9 39	9 28	9 27	9 33	9 44
15 9	1,475	Bellary .	9 52	10 4	9 59	10 4	10 5	10 9	10 4	10 5	9 53	9 39	9 39	9 45	9 55
15 52	2,524	Belgaum .	9 34	9 44	9 43	9 37	9 36	9 48	9 52	9 52	9 35	9 24	9 20	9 30	9 37
16 46	41	Rangoon .	9 45	9 53	9 53	10 1	9 55	10 5	10 10	10 12	10 2	9 43	9 37	9 37	9 54
18 28	1,840	Poona .	9 31	9 48	9 43	9 32	9 37	9 49	10 0	9 52	9 30	9 21	9 20	9 30	9 37
18 54	37	Bombay .	9 43	9 51	9 53	9 54	9 54	10 2	10 6	9 57	9 45	9 25	9 23	9 36	9 46
20 29	80	Cuttack .	9 49	9 57	9 54	9 50	9 56	9 58	10 4	10 1	9 51	9 34	9 34	9 37	9 50
21 9	1,025	Nagpur .	9 48	10 0	9 58	9 52	9 48	10 4	10 10	10 0	9 44	9 28	9 31	9 45	9 51
22 21	87	Chittagong	10 1	10 13	10 12	10 9	10 18	10 15	10 13	10 19	10 0	9 45	9 39	9 47	10 4
22 28	3,528	Pachmarhi .	9 54	10 1	10 2	10 3	10 8	10 11	10 16	10 6	9 59	9 42	9 43	9 45	9 59
22 32	21	Calcutta .	9 57	10 12	10 12	10 11	10 9	10 12	10 24	10 17	10 3	9 43	9 41	9 47	10 4
23 9	1,327	Jubbulpore	9 53	9 58	5 56	9 55	9 49	9 49	10 3	9 59	9 50	9 35	9 35	9 41	9 50
24 0	2,007	Hazaribagh	10 7	10 21	10 16	10 20	10 14	10 15	10 23	10 20	10 9	10 1	10 4	10 6	10 13
24 16	466	Deesa .	9 40	9 53	9 49	9 42	9 45	9 56	10 7	9 58	9 46	9 27	9 29	9 40	9 46
24 47	49	Kurrachee .	9 41	9 58	9 58	9 57	9 58	10 10	10 9	9 51	9 49	9 28	9 29	9 35	9 49
25 26	309	Allahabad .	9 54	10 3	10 4	10 1	10 6	10 9	10 16	10 7	9 58	9 44	9 37	9 47	9 59
25 37	183	Patna .	9 56	10 8	10 5	10 7	10 8	10 6	10 18	10 15	10 6	9 45	9 43	9 46	10 2
26 7	115	Dhubri .	10 3	10 2	10 13	10 23	10 22	10 11	10 19	10 16	10 9	9 47	9 43	9 50	10 7
26 11	386	Goalpara .	9 56	9 59	10 1	10 4	10 11	10 17	10 13	10 16	10 11	9 56	9 57	9 58	10 4
26 50	370	Lucknow .	10 4	10 11	10 8	10 9	10 3	10 23	10 18	10 15	10 4	9 54	9 50	9 54	10 6
26 55	1,431	Jaipur .	9 52	10 5	10 4	10 2	9 55	10 15	10 14	10 8	9 55	9 41	9 40	9 46	9 57
26 59	333	Sibsagar .	9 54	9 58	9 57	10 3	10 7	9 59	10 8	10 4	9 58	9 53	9 48	9 50	9 57
27 10	555	Agra .	10 0	10 6	10 7	10 3	10 13	10 18	10 19	10 15	10 5	9 48	9 48	9 51	10 4
29 52	887	Roorkee .	10 5	10 16	10 16	10 12	10 3	10 20	10 33	10 24	10 5	9 50	9 51	10 4	10 9
31 6	7,070	Simla .	10 24	10 34	10 31	10 26	10 26	10 34	10 44	10 33	10 15	10 0	10 2	10 12	10 23
31 34	702	Lahore .	10 21	10 36	10 28	10 22	10 17	10 22	10 35	10 24	10 6	9 56	9 57	10 16	10 23
34 10	11,503	Leh . .	9 48	10 3	10 6	9 58	9 52	9 50	9 58	10 22	9 47	9 49	9 49	9 49	9 54
34 4	5,204	Srinagar .	10 17	10 23	10 16	10 2	10 11	10 7	10 44	10 17	10 10	10 4	10 7	10 15	10 15

TABLE CXX.—*Showing the epochs of the third component* (U_3) *of air pressure.*

Latitude North.	Elevation in feet.	STATION.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Year.
° ′			H. M.	H. M.	H. M.	H. M.	H. M.	H. M.	H. M.	H. M	H. M.	H. M.	H. M.	H. M.	H. M.
8 31	195	Trivandrum	1 34	1 27	1 20	1 37	4 34	6 6	5 19	4 51	1 55	1 17	1 35	1 36	1 33
8 37	6,200	Agustia .	1 30	1 14	5 19	4 37	4 56	4 59	5 3	5 9	4 58	2 41	1 57	1 37	3 52
10 50	255	Trichinopoly	2 22	3 31	5 25	4 11	5 3	6 0	5 28	4 37	3 51	2 8	2 10	2 0	3 15
12 45	94	Aden .	1 35	1 35	1 27	2 4	2 46	4 55	5 50	4 33	0 45	2 16	1 42	2 12	2 14
13 4	22	Madras .	1 9	1 3	0 23	5 55	5 36	5 31	5 4	5 25	6 35	0 46	0 57	0 50	0 27
15 9	1,475	Bellary .	2 11	2 22	1 11	7 9	6 33	5 41	5 30	5 28	3 12	2 7	2 5	2 15	2 23
15 52	2,524	Belgaum .	2 5	2 10	2 13	3 43	6 12	6 43	7 34	5 32	2 24	2 18	1 31	2 0	2 11
16 46	41	Rangoon .	1 54	1 52	2 19	2 33	5 18	6 9	6 7	7 15	3 19	1 56	2 7	1 47	1 57
18 28	1,840	Poona .	1 58	2 6	2 17	5 7	7 0	6 9	6 26	5 21	2 34	2 8	2 6	1 42	2 4
18 54	37	Bombay .	2 3	2 0	1 35	7 49	6 17	6 18	6 22	6 8	2 43	2 3	1 46	1 54	1 45
20 29	80	Cuttack .	2 25	2 29	2 51	4 30	5 13	5 52	5 13	4 17	2 52	1 36	1 50	1 45	2 30
21 9	1,025	Nagpur .	2 13	2 18	2 52	5 33	5 43	5 30	5 47	4 51	3 5	3 0	1 56	2 17	2 46
22 21	87	Chittagong	1 59	1 57	0 40	6 21	6 26	6 25	6 14	5 25	2 25	1 51	1 43	1 51	1 27
22 28	2,528	Pachmarhi.	2 28	2 29	2 48	4 33	4 57	5 29	5 21	4 46	3 44	2 16	2 30	2 19	3 12
22 32	21	Calcutta .	2 11	2 9	1 53	5 25	5 27	5 45	5 55	5 25	3 54	2 11	1 57	2 3	2 24
23 9	1,327	Jubbulpore.	2 17	2 15	2 13	1 15	6 43	5 0	5 37	5 21	2 45	1 23	1 39	2 6	2 12
24 0	2,007	Hazaribagh	2 16	2 15	2 29	6 26	5 47	6 1	5 47	5 7	3 13	2 5	2 27	2 13	2 34
24 16	466	Deesa .	2 19	2 42	2 37	3 38	5 52	5 50	6 19	5 41	1 43	1 37	1 35	2 1	2 23
24 47	49	Kurrachee.	2 3	1 45	1 38	7 54	6 44	6 17	6 3	6 52	1 43	1 44	1 53	2 5	1 33
25 26	309	Allahabad.	2 4	2 15	1 44	6 14	6 19	5 54	5 43	5 19	3 52	1 46	1 55	2 1	2 13
25 37	183	Patna .	1 46	1 58	1 53	6 28	6 12	5 56	5 40	5 27	4 18	1 26	1 39	1 52	1 34
26 7	115	Dhubri .	2 9	2 10	2 13	6 37	5 58	5 38	5 44	5 19	4 25	2 22	2 0	2 4	2 37
26 11	386	Goalpara .	2 5	2 5	1 42	7 43	6 23	5 56	5 26	5 16	2 51	1 53	1 57	2 3	2 2
26 50	370	Lucknow .	2 18	2 23	2 22	4 0	6 11	5 50	5 34	4 29	2 54	1 39	1 55	2 10	2 28
26 55	1,431	Jaipur .	2 16	2 25	2 29	5 25	5 20	6 14	6 9	5 25	3 17	2 4	2 6	2 14	2 35
26 59	333	Sibsagar .	2 16	2 38	2 58	2 37	3 15	3 59	4 7	4 5	2 59	2 18	2 26	2 26	2 46
27 10	555	Agra. .	2 13	2 14	2 25	5 26	6 13	6 4	6 15	6 10	6 32	2 16	1 54	2 15	2 21
29 52	887	Roorkee .	2 16	2 12	2 50	5 53	5 28	6 16	6 4	5 11	2 17	1 44	1 56	2 14	2 43
31 6	7,070	Simla .	2 18	2 0	2 36	4 4	5 44	6 19	6 20	5 40	3 44	2 11	1 48	2 18	2 19
31 34	702	Lahore .	2 25	2 52	2 50	4 19	5 52	5 58	5 58	5 56	2 50	2 18	2 4	2 21	2 54
34 10	11,503	Leh . .	2 7	2 9	2 0	1 23	0 45	0 48	1 17	3 3	2 29	2 23	2 4	2 10	2 0
34 4	5,204	Srinagar .	1 18	2 27	1 51	7 27	7 22	0 3	7 16	0 25	2 0	1 37	1 41	2 9	1 5

TABLE CXXI.—*Showing the epochs of the fourth component* (U_4) *of air pressure.*

Latitude North.	Elevation in feet.	STATION.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Year.
° ′			H. M.	H. M.	H. M.	H. M.	H. M.	H. M.	H. M.	H. M.	H. M.	H. M.	H. M.	H. M.	H. M.
8 31	195	Trivandrum	4 10	3 59	4 4	4 29	4 44	4 24	4 6	3 56	3 59	3 43	3 33	3 11	4 0
8 37	6,200	Agustia	4 38	4 27	4 6	4 0	3 59	4 1	3 15	4 3	3 42	3 37	3 55	4 15	3 59
10 50	255	Trichinopoly	3 48	4 16	4 5	3 9	2 51	2 24	1 59	3 45	3 56	3 32	3 24	3 36	3 30
12 45	94	Aden	5 35	5 7	4 50	4 14	4 38	1 13	4 35	5 15	4 51	3 56	3 2	3 53	4 30
13 4	22	Madras	5 19	5 15	5 13	4 53	4 3	3 18	3 34	4 48	5 5	4 59	4 39	5 2	4 47
15 9	1,475	Bellary	4 26	5 5	4 30	0	0	3 53	0 34	2 23	5 8	4 7	3 40	4 9	4 30
15 52	2,524	Belgaum	3 37	3 34	3 45	2 9	4 9	2 33	1 30	3 40	4 22	4 7	3 52	3 25	3 45
16 46	41	Rangoon	3 45	4 3	4 54	2 51	2 13	2 30	2 50	3 7	3 12	4 57	4 3	3 40	3 15
18 28	1,840	Poona	3 39	3 24	3 31	2 29	2 4	0 53	3 11	2 39	3 31	3 17	3 14	3 34	3 21
18 54	37	Bombay	3 20	3 57	3 59	2 34	0 35	0 53	1 47	4 30	3 38	3 21	3 24	3 23	3 28
20 29	80	Cuttack	3 39	3 54	2 46	2 15	1 26	1 7	0 11	2 31	3 0	3 28	3 23	3 54	3 23
21 9	1,025	Nagpur	3 41	3 41	3 0	4 3	0 53	2 15	3 51	2 53	3 56	3 49	3 37	3 38	3 27
22 21	87	Chittagong	4 12	4 30	3 48	3 52	5 48	2 22	4 7	4 44	5 33	3 58	3 29	3 52	3 52
22 28	3,528	Pachmarhi	4 11	4 20	4 18	5 23	0 31	0 23	1 30	4 52	0 45	3 45	3 47	3 54	4 16
22 32	21	Calcutta	3 50	3 40	4 21	2 26	3 12	1 39	3 7	3 42	3 53	3 35	3 43	3 48	3 42
23 9	1,327	Jubbulpore	3 34	3 53	3 27	5 49	0 9	5 43	5 51	5 45	3 14	3 9	3 36	3 31	3 45
24 0	2,007	Hazaribagh	3 32	3 51	2 33	2 12	2 54	1 38	2 24	3 13	0 27	3 32	3 28	3 56	3 14
24 16	466	Deesa	3 54	3 40	3 53	2 26	2 9	2 15	2 10	2 25	4 44	3 38	3 34	3 42	3 29
24 47	49	Kurrachee	3 51	3 27	1 30	0 45	0	2 23	1 0	2 43	2 15	3 38	3 42	3 48	3 27
25 26	309	Allahabad	3 45	3 38	3 45	2 15	4 30	1 30	1 9	0 18	1 47	3 30	3 41	3 46	3 23
25 37	183	Patna	3 39	4 33	4 26	0	0	4 0	0 6	1 5	0 42	4 15	4 5	3 59	4 11
26 7	115	Dhubri	3 32	5 4	3 31	2 54	3 16	3 34	2 23	2 9	3 56	3 30	3 42	3 44	3 39
26 11	386	Goalpara	3 20	3 30	2 31	1 7	2 58	1 9	2 38	3 0	3 32	3 23	3 20	3 43	3 3
26 50	370	Lucknow	3 46	3 27	5 42	2 33	5 39	1 30	1 2	0 22	1 7	3 0	3 37	3 56	4 12
26 55	1,431	Jaipur	3 41	3 49	0	1 2	5 44	4 3	1 9	1 51	2 26	3 18	3 47	3 42	3 31
26 59	333	Sibsagar	3 19	3 12	2 12	2 14	2 18	2 23	2 17	2 25	2 51	2 52	3 19	3 23	2 46
27 10	555	Agra	3 56	4 7	3 15	3 4	2 7	2 49	1 47	2 43	3 5	3 53	3 18	4 4	3 28
29 52	887	Roorkee	4 3	5 6	4 23	5 37	1 13	0 21	1 19	5 26	5 6	4 22	4 1	4 2	4 25
31 6	7,070	Simla	3 50	4 27	4 41	2 30	1 38	1 32	1 36	4 14	4 3	3 52	3 13	3 45	3 6
31 34	702	Lahore	3 50	5 2	2 15	2 10	0 6	1 3	2 7	2 8	0 54	3 27	3 58	3 41	3 22
34 10	11,503	Leh	3 43	4 51	2 29	3 14	1 35	1 47	2 28	2 19	2 45	3 25	3 56	4 0	3 14
34 4	5,204	Srinagar	5 3	5 37	5 32	5 43	1 17	5 49	1 3	0 42	0 39	0 45	5 17	5 16	5 46